metals and alloys

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TREATMENT APPLICATION

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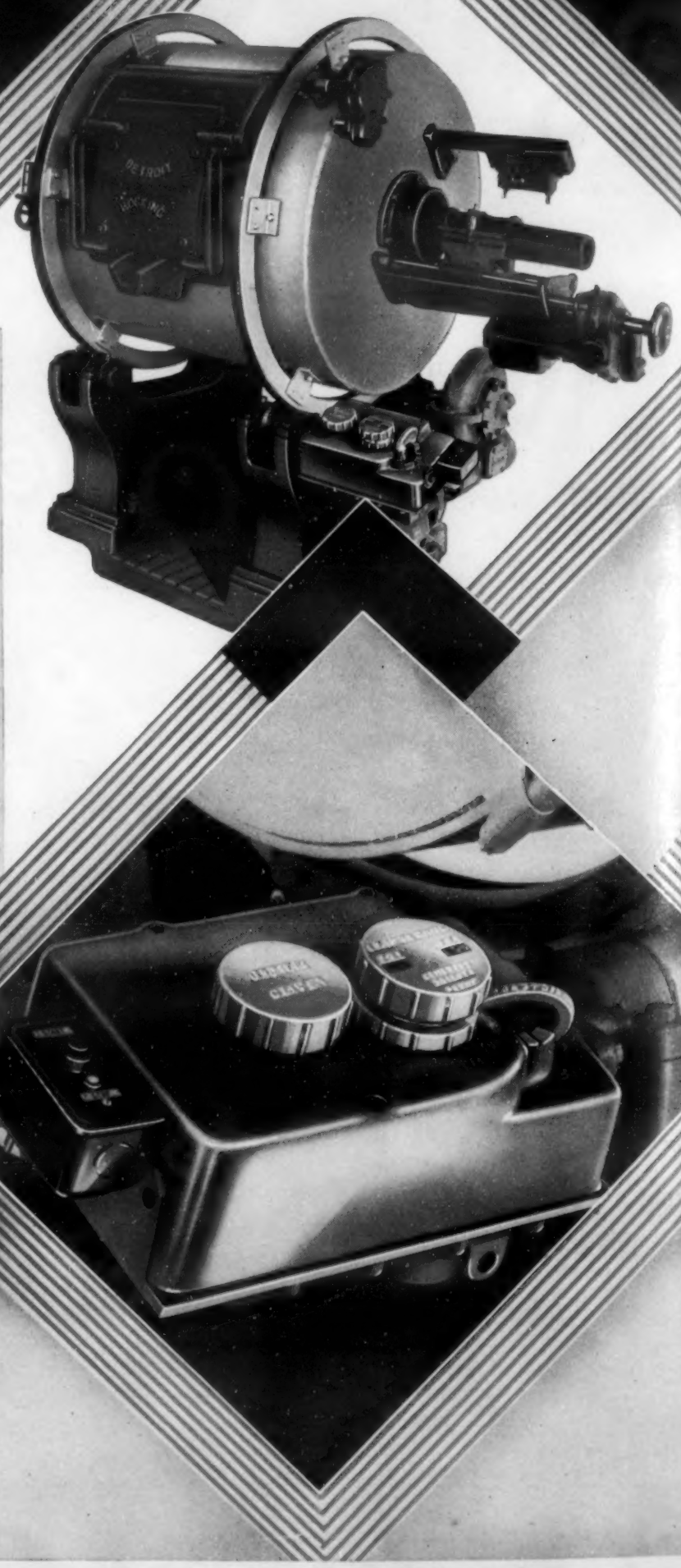
AUTOMATIC MELTING CONTROL



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HIGHLIGHTS

Written by the Abstract Section Editors and the Editorial Staff

DO YOU want to know what metallurgical engineers are saying, the world over? Look in the Current Metallurgical Abstracts. Here are some of the points covered by authors whose articles are abstracted in this issue.

A Summary of Vapor Pressures

Here's another time saver for the busy metallurgist—vapor pressures for 242 inorganic substances are summarized and discussed in Bureau of Mines *Bulletin* 383 (page MA 481 L 3). Such a compendium of basic information will facilitate the use of fundamental metallurgical data by the busy operator.—A.H.E.

Smelting Zinciferous Charges in Lead Blast Furnaces

The smelting of zinciferous charges in the lead blast furnace has been studied in great detail by the Bureau of Mines at Trail. The results, presented in five reports (page MA 481 L 4) are applicable to American furnaces.—A.H.E.

Data on Sintering

Sintering seems to be of increasing interest to metallurgists. Sintering the charge to lead and to iron blast furnaces is discussed in two abstracts (page MA 481 L 4 and MA 481 R 7).—A.H.E.

Poor Technique and a Russian Blast Furnace

Pozin and Shapovalov give an amusing article on a blast furnace in Russia, built on a bum foundation, which tilted like the leaning tower of Pisa (page MA 481 R 3). The amazing frankness of many Russian technical writers in recording how poor the technique has been in their plants gives a sidelight on what happens in regimented government operation. In this case the poor coke quality and the lack of engineering ability stick out like sore thumbs.—H.W.G.

Again—Oxygen in the Air Blast

Periodically the oxygen enrichment of the air blast to metallurgical furnaces comes to the fore. In step with its present ascendency are two abstracts (page MA 481 R 5 and MA 481 R 8).—A.H.E.

Charcoal Puts Gas into the Metal

Keeley (page MA 482 R 6) points out that charcoal, as a cover in non-ferrous melting, can not only do what it is supposed to do, but also something it isn't supposed to do: i.e., put gas into the metal.—H.W.G.

Two Notable Books Reviewed

Two especially notable books of very wide interest are reviewed this month—"The Cast Metals Handbook" of the A.F.A. (page MA 517 L 2) and "Modern Uses of Non-Ferrous Metals" from the A.I.M.E. (page MA 515 L 4).—H.W.G.

Hardening Hacksaws with Electric Heat

Trickett describes a neat electric heating method for hardening hacksaw blades (page MA 490 R 5).—H.W.G.

European News

Developments in Europe are of interest to combustion and metallurgical engineers in the United States. Of current interest are the Russian soaking pits described by Burianov and Kieselhof (page MA 492 L 3) and a new light annealing furnace in France reported by Sevastopoulo (page MA 492 L 2).—M.H.M.

Welding and the Modern Automobile

Recently an official of a concern making a popular-priced automobile was asked what part welding and cutting had played in producing it. He answered simply, "They made it possible." The full significance of his reply perhaps may be better appreciated when we recall that a recent article on the manufacture of the Ford V-8 stated that there were 3415 welds on the car: electric spot, flash and arc, and oxyacetylene (page MA 495 L5 and MA 495 L 6).—E.V.D.

Welded Steel Fabrication

Welded steel fabrication has become one of the outstanding recent developments in machine design and construction. By this method, assemblies are made from machine flame-cut hot-rolled steel plates and shapes, arc welded together. Steel castings are frequently welded into the structure for bearing, bosses and similar parts.

For a great variety of products, welded steel fabrication has proven a better, faster and cheaper manufacturing method, effecting remarkable savings in labor costs and floor space requirements. A remarkable flexibility and diversity of product may be obtained by fabrication from a small stock of quickly replaceable rolled plates and shapes, which incidentally are not subject to obsolescence.

The possibilities of welded steel fabrication incorporating the new low-alloy high-tensile and corrosion-resistant steels are just beginning to be realized. Entirely new fields are being opened and wise executives are watching this development with great interest (page MA 495 L 6).—E.V.D.

Tin Coatings Free from Pinholes

One of the most important applications of tin is its use as a coating on steel sheet. For coatings of ordinary commercial weight, it is impossible to insure freedom from "pinholing" in the coating. Likewise, tin coatings by electroplating are notably porous. By a recent development, however, whereby a thin electroplate of tin is deposited on a hot-dipped tin-coated surface, a resultant coating can be obtained which is invariably free from porosity even on very severely distorted areas (page MA 499 L 2).—H.S.R.

Inclusions

A method developed by Gutman (page MA 486 R 6) looks promising for a good separation of inclusions. Colloid chemistry to the front.—C.H.H.

Alloys of Tin

Phase diagrams for alloys of tin and 34 other elements have been summarized usefully in book form. They are accompanied by a discussion of interpretation of the diagrams and a complete bibliography (page MA 503 L 4).—J.S.M.

Thermal and Electrical Conductivity of Copper Alloys

One of those articles that will be referred to time and time again, both for its wealth of data and its authoritativeness, is the one on thermal and electrical conductivities of copper alloys by Cyril Smith and Earl Palmer (page MA 506 L 9).—H.W.G.

Properties of Some Metals and Their Alloys

Comprehensive accounts of the properties of the following metals and their alloys are abstracted in this issue: Calcium (page MA 506 L 10 and page MA 506 R 2); Lead (page 506 R 7 and page MA 508 L 1); Lithium (page MA 506 R 10) and Vanadium (page MA 508 L 2).—H.W.G.

Short-Time Creep Tests Better Than Long-Time Creep Tests?

After all the warnings we have had that it may be dangerous to base calculations of allowable stresses for high temperature service on the results of creep tests extending over only a few hundred hours, White, Clark and Wilson (page MA 511 L 3) report tests on two steels which gave a more conservative basis for such calculations from creep tests of 500 hr. duration than from similar tests of 1,000 hr.—L.J.

Some Valuable High Temperature Discussions

According to Bolton (page MA 511 R 2) a valve bronze with around 6 Sn, 4½ Zn, 2 Pb has better high temperature properties than the higher Sn 88-10-2. Other high temperature discussions by Kennedy (page MA 511 L 10) on Al alloys, by Bertschinger and Piwowarsky (page MA 511 L 8) on cast iron, by White, Clark and Wilson (page MA 511 L 3) on steels, testify to the widespread interest in high temperature properties.—H.W.G.

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The Editorial Advisory Board

(This Series was Started in the July Issue)

WILLIAM B. PRICE is chief chemist and metallurgist of the Scovill Mfg. Co., Waterbury, Conn. He was graduated with honors in chemistry at Sheffield Scientific School, Yale University, in 1902. In the fall of that year, Mr. Price was employed by the Scovill company as a chemist. Since 1906 he has been the company's chief chemist and metallurgist.

Regarded as one of the pioneer metallurgists of the brass industry, Mr. Price has done much to place the industry on a scientific basis. Recognizing the need of standardized methods for the chemical analysis of non-ferrous alloys, he wrote in 1911 the first book on brass analysis, "Technical Analysis of Brass."

Considerable original and constructive work has been credited to Mr. Price. Some of this includes: The development of fine grain Admiralty condenser tubes and improved methods of manufacturing these by the cupping process; improvements in developing free cutting brass rod; the application of technical control to manufacturing operations; formulation of standard specifications for non-ferrous alloys; and work on the nomenclature of metals and alloys.

Mr. Price is a member of the A.I.M.&M.E., S.A.E., A.S.T.M., A.C.S., Electrochemical Soc., Inst. of Metals (British) and Int. Assn. for Testing Mat. He is the author of numerous scientific papers presented before these and other societies. Many patents are credited to Mr. Price.

WILLIAM B. PRICE

LEO F. REINARTZ is works manager of the Middletown (Ohio) works of the American Rolling Mill Co. His early education was acquired at the East Liverpool (Ohio) high school and he was graduated in 1909 from the Carnegie Institute of Technology, Pittsburgh, as a metallurgical engineer. He has the degrees of B.S. and Met. E.

Following his graduation from Carnegie Tech., he was employed as a chemist by Armco at Middletown at the time the company was developing "Armco Iron." He has held successively, previous to his present position, the following: Open-hearth foreman, assistant superintendent and then superintendent of the open-hearth department, and assistant general superintendent.

Mr. Reinartz has been and is active in the A.I.M.&M.E., particularly in that organization's open-hearth committee, of which he is chairman. He is a past chairman of the iron and steel division of that society. He is a member of the Iron and Steel Institute (British); the American Management Association; secretary of the board of regents of Capital University, Columbus, Ohio; and treasurer of the Middletown Hospital Association.

LEO F. REINARTZ

HARRY A. SCHWARTZ is manager of research, National Malleable & Steel Castings Co., Cleveland. He was educated first in the public schools of Louisville, Ky., his native state. From the Rose Polytechnic Institute he was graduated in 1901 with the degree of B.S. (in E.E.). From the same institution he obtained his M.S. in 1903, his M.E. in 1905, and his Ch. E. in 1931.

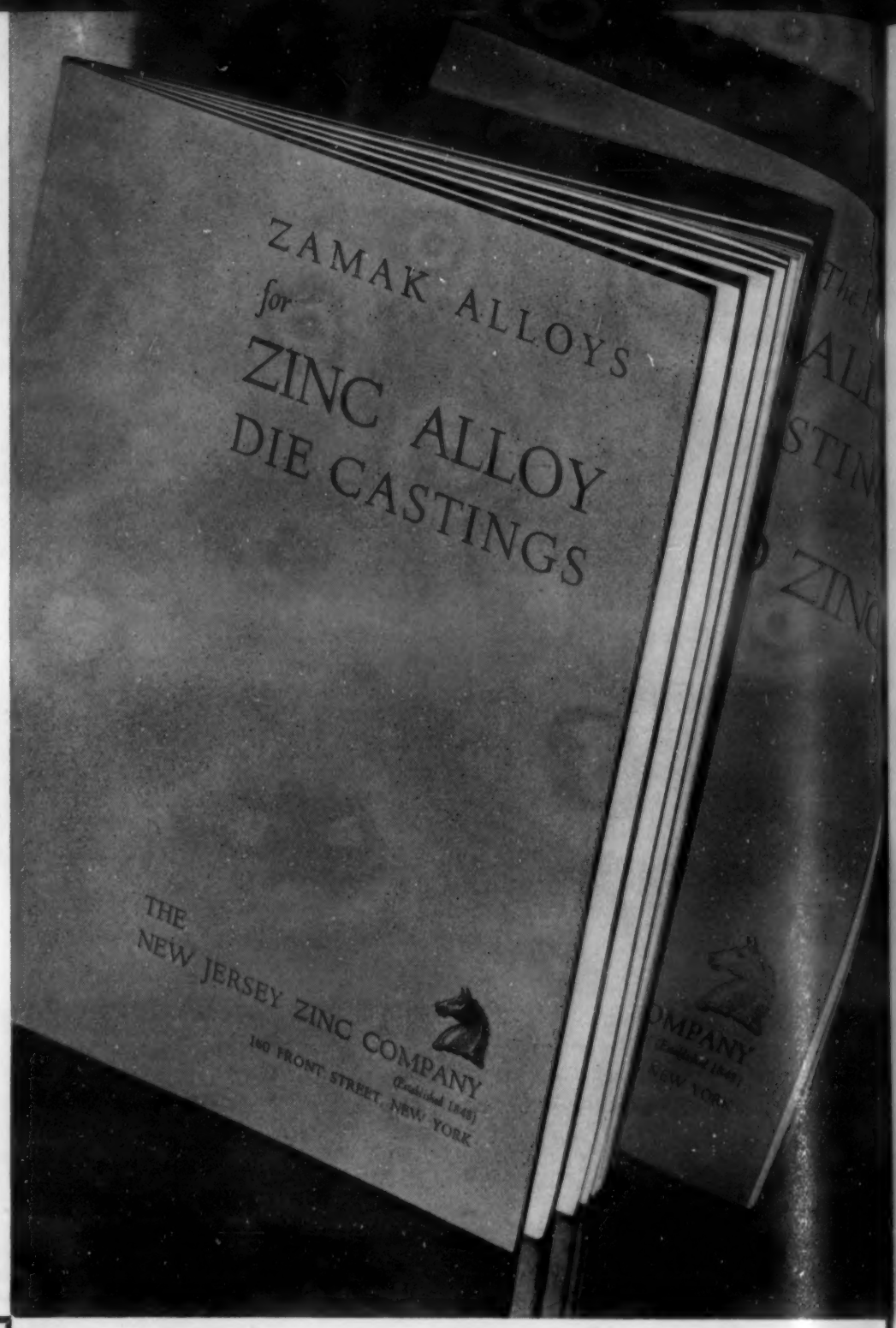
After one summer in the power plant of the Louisville Railway Co., Dr. Schwartz taught in the department of drawing and machine design at Rose, 1901-1902. From 1902 he was engaged in various chemical and engineering capacities by the National Malleable at its Indianapolis plant, and since 1920 has filled his present position.

Dr. Schwartz is a fellow of the American Association for the Advancement of Science, an honorary life member of the A.F.A. and a member of the A.C.S., A.S.M.E., A.I.M.&M.E., A.S.M., A.S.T.M. and the British Iron and Steel Institute. He was awarded the Penton Medal of the A.F.A. in 1931 and Rose Polytechnic bestowed on him in 1933 an honorary Sc.D. He is the author of the book, "American Malleable Cast Iron (Penton Co., 1922) and some 40 technical papers including, by invitation, contributions to the French and Belgian foundry congresses, the World Engineering Congress at Tokyo and the Bohemian Engineering Society. He is credited with some half dozen U. S. patents and is a special lecturer at Case School of Applied Science, Cleveland, on "Theory of Metallurgy" and on "Metallurgy of Cast Iron." He is a member of many committees of the A.F.A. and the A.S.T.M. His principal subject of investigation is "Genesis of Graphite in Cast Irons."

HARRY A. SCHWARTZ

Reports on a Major Achievement !

New Jersey zinc



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EDITORIAL COMMENT

Technical Society Memberships

WE were surprised to find from a statement by the American Society for Testing Materials, made in a campaign for new members, that its membership is still 20 per cent below what it was in 1930. We would guess that this loss probably reflects more a tightening up on company representative's dues in societies in general, than it does a change in the number of memberships that were paid for by individuals. Probably a good many firms who used to think it worth the cost to have their men active in or in touch with A.S.T.M. activities, fear that the back of the depression is only cracked and not yet broken and have so little faith in the present politically-minded administration's permanent attitude toward business that they feel forced to maintain this type of penny-pinching.

While we personally share the antipathy of such firms toward the myriad unsound governmental policies, we believe that technology is more permanent and potent than political expediency and that even in the depths into which the latter may plunge us, we shall continue to need better and more dependable materials. This need is basic and exists whether the New Deal comet is still flaring like a rocket or coming down like a stick. We therefore believe that company provision of A.S.T.M. membership and resumption of active cooperation in its work would be excellent policy.

There is a fundamental difference between most of the other technical societies and the A.S.T.M. The former tend primarily to act as media for the publication of papers of timely interest to their members and do very useful educational work. The A.S.T.M. performs these functions too, but its main work is in the establishment of specifications that facilitate buying and selling, and the maintenance of quality. In the specification work it almost invariably occurs that a need for a specification arises before there seems to exist adequate technical information upon which it can be drawn. In such a case the committee, having the matter in hand, seldom sits supinely by and waits for some one to bring in the needed information. It goes after it. If it really doesn't exist, as proven by a search among those who should have it, the committee rolls up its sleeves and digs in to get the data on a cooperative basis. Sometimes the task is too onerous to be thus handled, in which case, if the problem is really pressing, the committee is generally able to secure funds and hire the work done.

At any rate, the spirit of the A.S.T.M. is not merely passively to deplore the absence of information, but actively to do something about it. As a result much fundamental metallurgical information has been accumulated in the technical and research activities of various committees, some of which have been active for decades. This will to initiate, as well as to report, progress makes the society a potent factor in American metallurgy even though metallurgy is but one of its fields.

A similar situation besets the American Institute of Mining and Metallurgical Engineers, whose membership is down and which, like the A.S.T.M., reaches into fields other than metallurgy. The losses in membership of the American Society for Metals have, however, not only been regained, but have risen to an all-time high and that society deals wholly with metals.

It would be interesting to have a break-down of the membership changes in the two former societies to show whether the memberships not yet restored are chiefly in the petroleum, coal, cement, etc. industries, or chiefly in the metal industries. If they are in the last, then that portion of the metal industries that has not yet come back into the fold is missing an opportunity that it cannot afford to miss, whether the business prospects be rosy or dark. It would seem probable that the metal industries are the more forward looking of the lot.

A further break-down of all technical societies to show what proportion of the membership is personally paid for by the individual members and what by the firms for which they work, would also be highly interesting, were data available. We would guess for example that there are more personally-paid memberships in the A.I.M.E. and more company memberships in the A.S.T.M. If this be correct it would indicate that individuals are more alert in seeking technical information that will help them in their later career, than companies are.

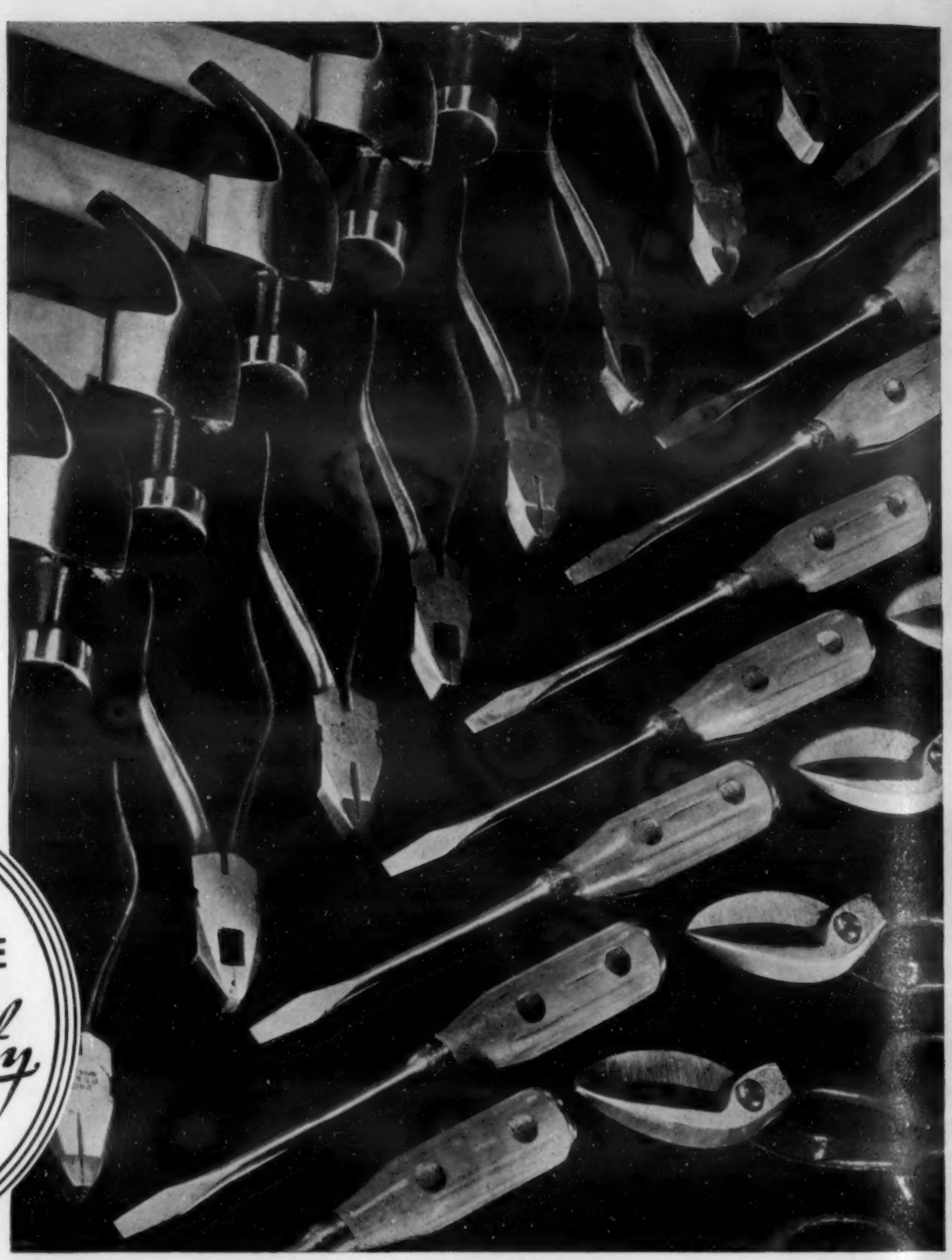
We know of no investment that would be better for a firm than the amount required to provide information for its technical men through memberships in technical societies and subscriptions to technical journals. In all too many cases memberships and subscriptions are not paid for by the firm when they should be. A man who wants to grow secures these sources of information at his own expense and even when he has grown into a responsible position and is pretty much of a fixture with his firm so that all the information he can get is a continuing asset to the firm, he continues to pay his own dues or subscriptions.

We suggest that many a man who is still paying his own, or who has been forced to drop them, as many had to do in the financial stringency, and who feels the need of the information he is not getting, ought to put the matter up to the firm. If he wants to send a marked copy of this in to the boss, it's all right with us. Or, he might write the secretary of the organization he wants to join or rejoin, or the circulation department of the journal he wishes and let them work on the boss.

Only in a complete absence of hope for future private business, such as a complete dictatorship without hope of its overthrow, or in a condition where the government will pay the steel, copper and aluminum industries for not producing those commodities, can we imagine the cessation of a need for the A.S.T.M., the A.I.M.E., the A.S.M. and their publications, and for other technical journals.

If that condition does arise here, we are either going to move to some un-regimented country, or quit being a metallurgist and put in all our time fishing. If they bite, all right, if not, we'll send in a bill to Washington

(Continued on page 335)



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Open-Hearth Roof Temperatures

By H. M. SCHMITT

Research Engineer, Brown Instrument Co., Philadelphia

THE EARLY ATTEMPTS at open-hearth roof insulation resulted in a short roof life due to the fact that an insulated roof has different characteristics than a bare roof and the pioneers in this field lacked both experience and adequate equipment to guide them. Preliminary studies of brick that had been through a campaign in an insulated roof indicate that the higher temperatures had a sort of refining action. The brick was more homogeneous than similar bricks taken from an uninsulated roof.

Studies in roof temperatures have led to the development of several types of practical equipment for continuously recording signalling and automatically controlling open-hearth roof temperatures.

Thermocouples Imbedded Under Insulation

In this method (see Fig. 1) a number of thermocouples, generally four or six, are distributed over the roof, and the corresponding temperatures are recorded on the same chart. Experience with a given furnace determines the exact locations where the temperature information is of most importance as over slag pots or over the tap hole.

The response of thermocouples located such as these is slow and lags behind inside furnace temperature so that fluctuations of the temperature of the inner face of the brick are pretty well damped out. It is therefore not adaptable for automatic control. It does, however, provide a progressive record of the condition of the roof and reaches its greatest usefulness as the roof becomes thinner to guide the operator in favoring the weak spots and thereby extending the life of the roof. The thermocouples may easily be shifted to new locations that show unusual wear.

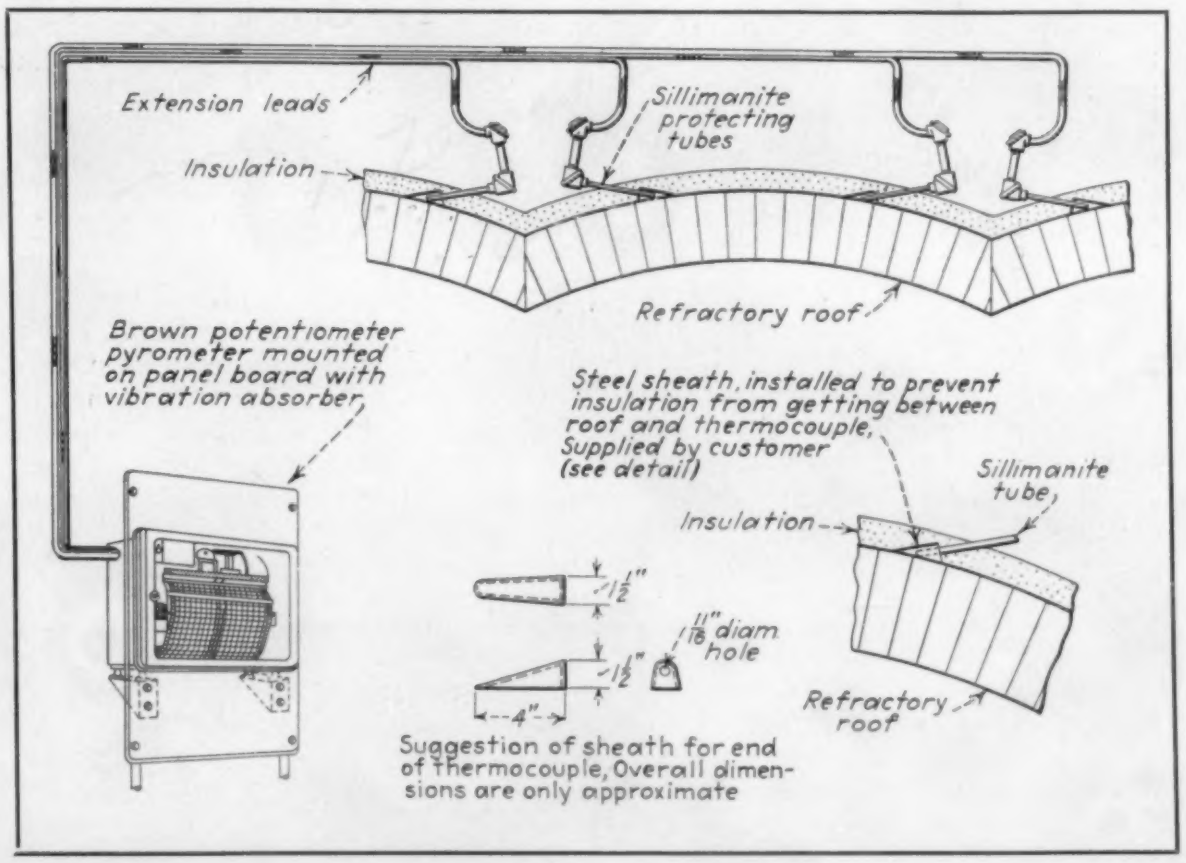

Extension leads
Insulation
Sillimanite protecting tubes
Refractory roof
Brown potentiometer pyrometer mounted on panel board with vibration absorber
Steel sheath, installed to prevent insulation from getting between roof and thermocouple, Supplied by customer (see detail)
Sillimanite tube
Insulation
1½"
11/16" diam hole
1½"
4"
Refractory roof
Suggestion of sheath for end of thermocouple, Overall dimensions are only approximate

Fig. 1. Thermocouples Installed under Insulation on Roof of Open-Hearth Furnace.

Thermocouples Inserted in Roof Brick

In this method the thermocouples are inserted in holes drilled into the roof brick. The depth, location and number of holes can be varied in an infinite number of combinations and experience with a particular furnace is the guiding factor in these details. This method has characteristics similar to that in which the thermocouples are placed under the insulation and may be used on uninsulated roofs. With the thermocouples in the brick, the response is faster and there is less damping of the temperature fluctuations in the furnace, but this method is still not sufficiently responsive for use with automatic control equipment. It does give a progressive record that can be interpreted in terms of roof condition.

Thermocouple Mounted in Refractory Insert in Water-Cooled Tuyere

The equipment for this method is mounted as shown in Fig. 2. The refractory insert is of a material having a high thermal conductivity in comparison with

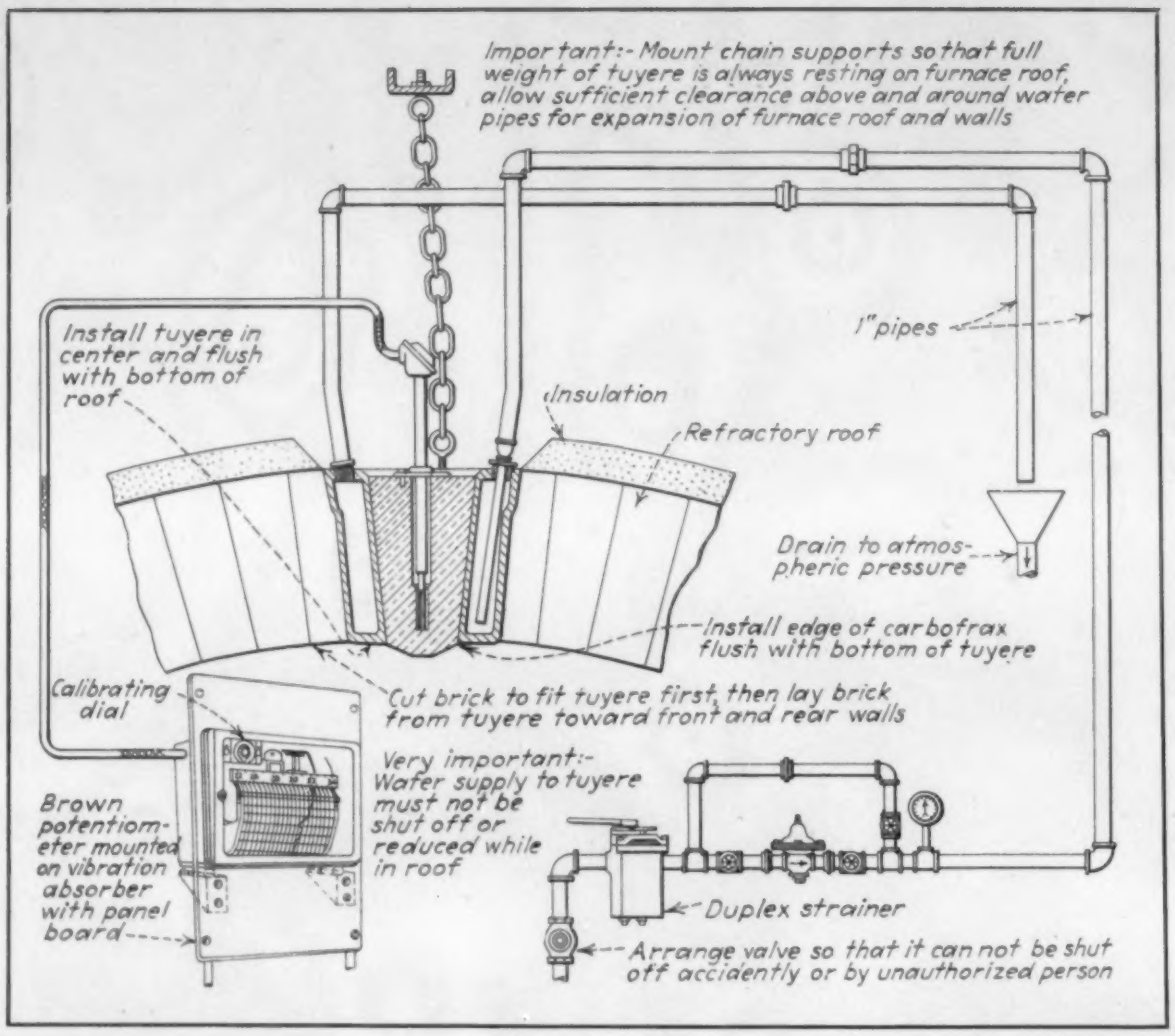

Important:- Mount chain supports so that full weight of tuyere is always resting on furnace roof, allow sufficient clearance above and around water pipes for expansion of furnace roof and walls
Install tuyere in center and flush with bottom of roof
1" pipes
Insulation
Refractory roof
Drain to atmospheric pressure
Install edge of carbofrax flush with bottom of tuyere
Calibrating dial
Cut brick to fit tuyere first, then lay brick from tuyere toward front and rear walls
Very important:- Water supply to tuyere must not be shut off or reduced while in roof
Brown potentiometer mounted on vibration absorber with panel board
Duplex strainer
Arrange valve so that it can not be shut off accidently or by unauthorized person

Fig. 2. Installation Drawing of Brown Tuyere Type Thermocouple with Carborundum Insert.

other refractories. The bottom of the refractory insert is about 1¼ in. thick and the thermocouple is in contact with the upper side.

The temperature in the insert varies from a maximum at the surface exposed to the furnace to a minimum at the surface in contact with the tuyere. Changes in water temperature produce but negligible changes in the slope of this temperature gradient through the insert and therefore do not influence the temperature of the point at which the thermocouple is located. To prevent steaming the flow of water through the tuyere is maintained such that the outlet temperature will not exceed 125 deg. F.

With this type of installation, the first two-thirds of a heat may be carried through with the pyrometer readings above what would normally be considered safe because they correspond to surface temperatures that have not "soaked" to a dangerous depth. During the final third of the heat, the temperature is lowered gradually because "soaking" progresses with time. The actual roof temperature at depths that would cause running then approaches the value indicated by the pyrometer. It is during this final third of a heat that the pyrometer readings become the operating guide.

The actual temperature of the termocouple is about 1800 deg. F. but the pyrometer is calibrated in terms of roof surface temperature. An optical pyrometer is sighted on a spot about 24 in. from the water cooled tuyere. These readings are taken during the last half hour before tapping when the furnace atmosphere has cleared. Experimental calibrations under flame-on and flame-off conditions indicate that more consistent results are obtained under the flame-on condition. It is true that flame reflection raises the apparent temperature but the readings are consistently high under normal operating conditions for the same furnace and they can be repeated within reasonable limits of accuracy. Under flame-off conditions, however, the roof temperature drops very rapidly and it is impossible to obtain consistent re-

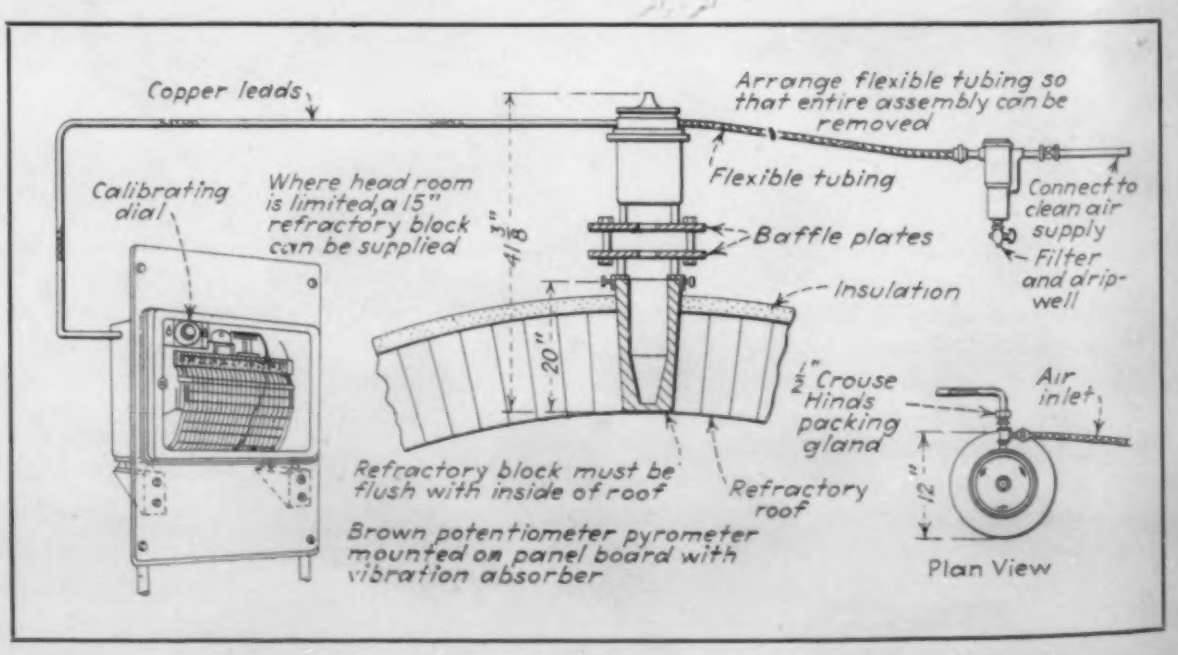

Copper leads
Arrange flexible tubing so that entire assembly can be removed
Flexible tubing
Connect to clean air supply
Filter and drip-well
Calibrating dial
Where head room is limited, a 15" refractory block can be supplied
3"
4 1/8
Baffle plates
Insulation
20"
½" Crouse Hind's packing gland
Air inlet
Refractory block must be flush with inside of roof
Refractory roof
Brown potentiometer pyrometer mounted on panel board with vibration absorber
Plan View

Fig. 3. Installation Diagram of Brown Air Cooled Radiation Pyrometer for Insulated Furnace Roofs.

sults. Calibrations checks at intervals of once every two weeks are sufficiently frequent to maintain the required accuracy.

Auxiliary equipment has been applied to this type of installation to automatically regulate the fuel supply to the open-hearth and thereby automatically control the furnace temperature. The gradual thinning down of the bottom of the refractory insert tends to make the temperature read higher and so would be in the direction of safer operation between calibrations. The magnitude of this drift is about 20 deg. F. per month in a number of installations made to date.

Radiation Pyrometer Sighted into Refractory Tube Mounted in the Roof

In this type of installation a hollow refractory block is mounted in the roof as shown in Fig. 3. A radiation pyrometer is clamped to the top of the block and sighted on the bottom of the hole.

The bottom of the tube is about 1 in. thick. There is no water cooling and the general conditions are such that the temperature of the inside of the bottom of the tube is the same as a similar location in surrounding blocks. As the bottom of the tube wears with the rest of the roof, discs of refractory material are inserted to maintain a bottom in the tube. Inserts last an average of ten weeks.

Calibration checks with this type of installation are similar to those described for the type of installation shown in Fig. 2. The radiation tube is purged with clean compressed air. This serves to cool the tube to a sufficiently low operating temperature and also maintain a clean atmosphere in front of the tube.

The pyrometer readings may be interpreted in terms of "soaking" or heat penetration into the roof and are important as a guide as dangerous temperatures are approached. Auxiliary signalling and alarm equipment may be used to announce when these temperatures have been reached or a high limit cut-off may be applied to automatically reduce the fuel supply.

Summary

The four types of installations described provide continuous records, each having its own characteristics, yet all can be interpreted to focus on the same common objective—lower cost per ton of metal produced.

Investigations of open-hearth roof temperatures, following the early experiments with insulation, have created a general fund of knowledge about roof temperatures and refractories by the application of which the average life of both bare and insulated roofs may be extended. Thanks to the pioneers for having started a practice that will ultimately benefit the entire industry.

EDITORIAL COMMENT

(Continued from page A 23)

for payment due for not catching fish. However, we haven't started to pack up or throw away our metallurgical books and journals, for we don't believe the country is going to be permanently regimented. When the Supreme Court is packed with men of Townsendite leanings, when Henry Ford signs up with a new N.R.A., and the Saturday Evening Post comes in with its editorials blacked out, we'll start packing—till then we'll live in hopes.

And till then technical society memberships will be assets.—H. W. G.

Super Refractories for the Open Hearth

TWO fundamental limiting factors control the capacity of the open-hearth furnace—time and temperature. Shortening the time of the heat will require higher temperatures but the limit has practically been reached so far as the present type of refractories is concerned. These facts were called to attention by Dr. Frank J. Tone, president of the Carborundum Company, in his address on "Super-Refractories," delivered when he accepted the Acheson Medal from The Electrochemical Society recently.

As bearing on the possibility of overcoming some of these limiting factors, Dr. Tone revealed the fact that his company's researches on the properties of a fused chromite, a new product in refractories, give promise of increasing the life and efficiency of open-hearth refractories. He stated that it has been found that castings composed largely of certain types of such chromites are extremely promising for replacing water-cooled cast iron port corners and for use in other severe locations below the furnace roof.

This is decidedly interesting and perhaps prophetic when it is considered that the silica roof is now the limiting factor. Undoubtedly lower cost steel made in less time would result from the development of a suitable refractory. It is not improbable that we are on the threshold of some important developments in open-hearth practice. It may be added that there are other super refractories on the horizon.—E. F. C.

Again—What Is An Alloy Steel

"WHAT is an Alloy Steel" is still a question to which there is yet no satisfactory nor conclusive answer,—at least one on which there can be general agreement. We discover, however, that the American Iron and Steel Institute in its 1934 survey of alloy steels promulgates, for the first time, the steels which it considers to fall under alloy classification. A steel is not an alloy steel if the minimum of the range specified in any of the elements exceeds the following percentages:

Ni	—	0.40
Cr	—	0.30
Cu	—	0.50
Mn	—	1.65
Si	—	0.50
Mo	—	0.10
V, W Co, Ti, Zr	—	Any percent

It is on the basis of this classification that the Institute's statistics of the production of alloy ingots and castings are now compiled.

There are manifest exceptions which can be taken to this classification. A glaring one is the manganese content of 1.65 per cent. A majority of metallurgists would define a medium manganese steel, containing 1.00 per cent or more, as an alloy steel. Many would

include copper-bearing steel as an alloy steel. Others assert that phosphorus is, or will soon be, regarded as an alloying element. Why should a carbon-vanadium steel with as low as 0.05 per cent vanadium be considered an alloy steel when at the same time a carbon-molybdenum steel with 0.08 or 0.09 per cent molybdenum would be thrown out as an alloy steel. And so on.

Some years ago we obtained from some twenty-five leading American metallurgists their opinions as to what really constitutes an alloy steel. The result of this survey was published in *The Iron Age*. A definition which was formulated as a result of this survey was as follows:

> An alloy steel is one that, because of the addition of metallic elements other than those already present in plain carbon steels, or by the considerable increase in the metallic elements, silicon or manganese, usually present in plain carbon steels, differs markedly in physical properties, mechanical, electric, etc., or in resistance to atmospheric or chemical action whether at normal or at elevated temperatures, from plain carbon steel.

In the light of present knowledge and research, this would have to be modified to include phosphorus and perhaps sulphur.

In any event we feel that this definition, or one that is equally as broad, more nearly meets the needs of the industry, particularly as a basis for classification, than the method of the Institute.

Again we make a plea that some joint committee of at least two technical societies survey this subject and recommend a standard definition.—E.F.C.

A Bibliography on Galvanizing

DR. KRIVOBOK writes us that he has found a buried treasure in the Carnegie Library in Pittsburgh—a very complete list of all publications on galvanizing for the past 25 years. There seems to be no likelihood of immediate publication, but knowing the great courtesy with which visitors to the Library are received, we are sure that anyone who goes to Pittsburgh will find it available there, and we take this means of calling its existence to the attention of our readers.

Few biblographies will pay back the cost of publication, to say nothing of the cost of preparation, so, to make them available, their publication needs to be subsidized. How this might be accomplished is a problem not easily solved, but worthy of attention.

LETTERS TO THE EDITOR

"Scrambled Technology"—A Protest

To the Editor: "Scrambled Technology" is a term proposed to describe the method, used extensively lately by certain trade papers and other publications, of presenting technical and other articles in a scrambled condition. By this is meant articles mixed with advertising to the extent that it is exceedingly difficult for the reader to pursue with continuity and peace of mind the discussion to its conclusion. This practice may be justified, even though bad, in the more popular journals, but in a technical or semi-technical discussion, it is prejudicial to the best interests of the reader. Primarily, a technical journal is published for the enlightenment and convenience of its readers and these are best served, it is thought, by continuity of text. At the same time, it is recognized that the depression has upset some conservative and worthwhile publication customs; nevertheless, the plea is made hereby that the old-time methods be restored. METALS & ALLOYS is to be commended for having resisted the upset and it is hoped that METALS & ALLOYS will continue to resist. It has been found that other readers agree with this protest, recommendation, and commendation.

J. S. Marsh

New York

Alloys of Iron Research

We expect to continue to resist—Editors.

Are Metallurgical Experts Needed?

To the Editor: We just had a little family experience which reminded me strongly of you, and made me wonder incidentally if metallurgical experts are really needed. My young son was put-putting along in his 1924 Model T (@ $16.50 per) the other day when with a loud crash, she stopped dead. The noise had come from under the hood. It wasn't the source of the noise but its ominous nature that gave him pause and his worst fears were found later to be justified by the facts.

After getting back home finally and getting a look inside, my son found he had a broken crankshaft on his hands. At once he asked me, his father, what caused that shaft to break. Not his father, but the metallurgist, replied; "When you get it out I'll be glad to examine it and see if I can figure out the cause of the failure." So there it rested for a while but a few days later he came in, with his face radiant; "Dad, I know why my crankshaft broke; the man at the filling station told me it had crystallized." There was just the faintest suggestion too,—why didn't I know such things? My own thoughts were more like,—"Shades of Dr. Gillett," and "This from a son of mine, horrors"! In a way, though, I was on the spot so my young son got a little lecture on fatigue failures and some of their causes. I can only hope that, in his estimation, I am at least as expert as his filling station counsel.

Note: If you ever get up a fund to have Kate Smith or Eddie Cantor do a bit of broadcasting on this point, please count me in.

Samuel L. Hoyt.

A. O. Smith Corp.
Milwaukee.

Cellophane As a Pipe Line Coating

To the Editor: I noticed in your "High Lights" section of the September issue of METALS & ALLOYS under the paragraph caption, "Overcoat for Turbines," (page A23, September) that Bredburg mentions celluloid as a wrapper for pipe line coatings. You have added the line "cellophane is still to be suggested." You will perhaps be interested to know that cellophane has not yet to be suggested as we have completed a four-year and four-months underground test of this material. Incidentally, in our tests of celluloid vs. cellophane, celluloid was the better material.

Walter F. Rogers.

Gulf Pipe Line Co.
Houston, Texas

Pure Wrought Zirconium Metal

To the Editor: We always enjoy reading the facetious little reviews under "High Lights" in METALS & ALLOYS and note your reference to wrought zirconium in the September issue (page A23—September). We thought you might be interested in examining a sample of pure wrought zirconium metal and also in knowing that it is actually being produced on a commercial scale. A piece of pure zirconium metal foil is attached. The wire has been used in radio tubes and the sheet metal in spinneret cups for rayon manufacture.

H. C. Myer.
Vice-President

Foote Mineral Co., Inc.
Philadelphia

Brass and Copper Forgings

Their Manufacture, Properties and Uses

By EDWIN F. CONE

AN IMPORTANT PHASE of the non-ferrous industry, the possibilities of which have not been exploited to the extent they are believed to deserve, is the forging of brass and copper. With this should be included the forging of several other copper-base alloys.

The most prominent development commercially in this field up to the present time has been the production of brass forgings. As a whole the industry in this country dates back approximately 20 years. It is therefore not an old art though the casting of these products is of course many years older, anticipating iron and steel products.

While some little development work has been done with copper and brass forgings, it is the opinion of some large producers that the properties of brass and copper forgings are such that there is a large opportunity to further extend the applications of these products in engineering fields.

With these general objectives in view, it is the aim of this article to present a general discussion of the production of brass and copper forgings. In obtaining information for this article, one of the large American producers—The Revere Copper & Brass, Inc., which has forging departments at its Rome Manufacturing Division at Rome, N. Y. and at its Dallas Division in Chicago—has cordially cooperated. Because of the predominance of the output in brass forgings over copper forgings, these will be mainly discussed with digressions as to copper forgings and later some reference to forgings of other copper-base alloys.

Forgings and Castings Compared

Brass forgings at once suggest brass castings which have many useful qualities. Advocates of the forgings point to several superior advantages over castings. The production of a brass forging involves a saving of metal. If proper die design is assured, less machine work is necessary on a forging. Greater density, freedom from porosity and additional strength are characteristic of the forged brass. It is possible in many cases to secure such close control of dimensions in the die that machining of the final product is unnecessary. In preparing parts for nickel and other plating, there is a saving in polishing operations in the case of the forging. Forgings are free from sand, blow-holes and other foreign matter which are encountered in castings and which dull cutting tools in machining operations.

The physical properties of the forgings as well as of the castings depend, among other factors, upon their microstructure. Photomicrographs, Figs. 1 and 2, show the average structure of a good quality sand casting of brass and of a regular brass forging respectively. The fine uniform grain structure of the forging is a feature. The same materials at higher magnifications are shown in Figs. 3 and 4. The comparative physical properties average about as follows:

	Good Quality Sand Castings	Brass Forgings	Copper Forgings
Tensile strength, lb. per sq. in.	20,000	40,000 to 50,000	30,000 to 35,000
Elong. in 2 in., per cent	17.0	20.0 (min.) to 55.0	35.0 to 50.0
Brinell	60	70 to 82	40 to 50

Presses and Hammers Used for Brass and Copper Forgings at the Dallas Division of the Revere Copper & Brass Co., Inc.

Raw Material for Brass Forgings

For the forging of brass the raw material is extruded rods of various dimensions and shapes. For the most part they are round or square but special irregular shapes are sometimes employed. In the latter case their use involves a saving of metal and insures better forgings. For copper forgings the raw material is hot rolled rounds or squares of virgin metal. Sharp edges on forgings are not desirable from a production point of view, and when possible, parts to be forged should be designed with rounded edges.

In general the composition of the brass for forging conforms to S. A. E. specification No. 88 as follows:

Copper	58.5 to 61.5 per cent
Lead	1.5 to 2.5 per cent
Other than Cu, Pb, Zn	0.50 max. per cent
Zinc	Balance

The lead is introduced into the standard 60-40 brass to increase its machining properties.

Forging Equipment Used

Brass forgings, and also copper, are either press or hammer forged products. The equipment usually used, as represented by that at the plants of the Revere company, is as follows:

Presses—Crank, knuckle or screw
Hammers—Board or Steam

The presses vary in capacity from 150 to 450 tons each while the hammers are rated at 400 to 2,500 lb. each. They are in each case regular standard equipment. The bulk of the work is done on equipment of these capacities. If forging were utilized as a means for fabricating larger parts, equipment of greater capacity would be used.

Each press or hammer has, close to it, a heating

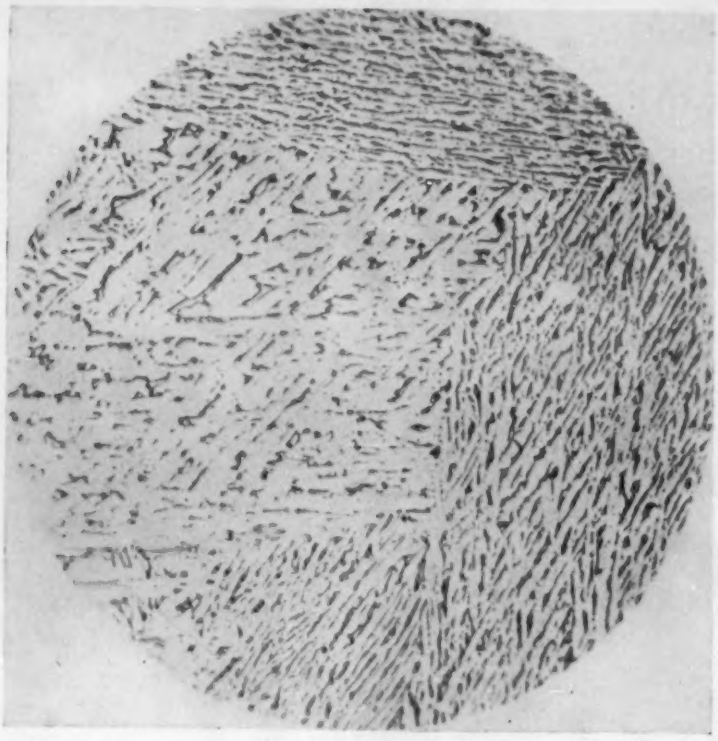


Fig. 1. Structure of a Good Quality Brass Sand Casting. Magnification, 50 diameters.

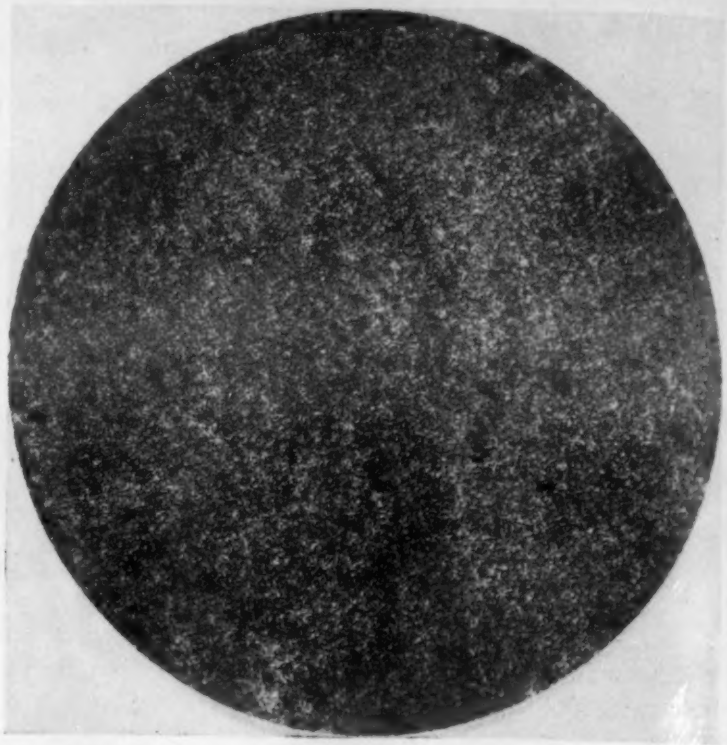


Fig. 2. Structure of a Representative Brass Forging. Magnification, 50 diameters.

Fig. 3. Same as Fig. 1 except at a Magnification of 500 diameters.

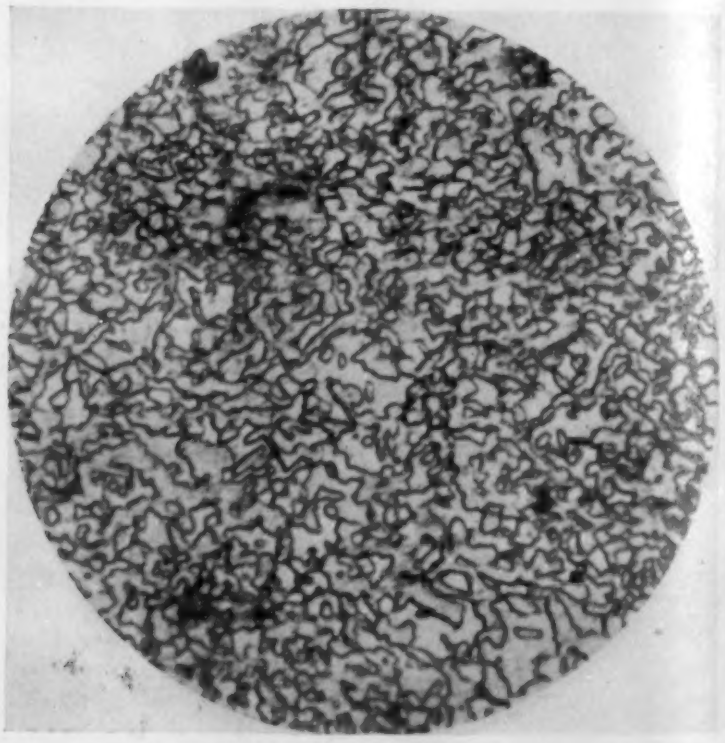


Fig. 4. Same as Fig. 2 except at a Magnification of 500 diameters.

furnace in which the metal to be forged is pre-heated. Usually the temperature is carefully controlled by pyrometers but the atmosphere is only partially regulated. The general aim is to keep this neutral and to avoid contact of the flame with the material to be forged.

The Dies, Their Composition and Life

The dies are a vital part of the equipment, whether in presses or hammers. In general the type of steel used in the hammers is a chrome-nickel-molybdenum steel. In the presses two types of chrome-vanadium-tungsten steels are used. The press dies have to be properly hardened after cutting the impression; the hammer dies are used without further heat treatment after the die has been cut.

In general, a longer die life is obtained with the hammer dies than with the press dies. While die cost is an important factor in the cost of forgings, it is nevertheless true that, depending upon the size and design of the part, other variable cost factors must be taken into consideration and it must not be concluded that hammer forgings are more expensive to produce than press forgings.

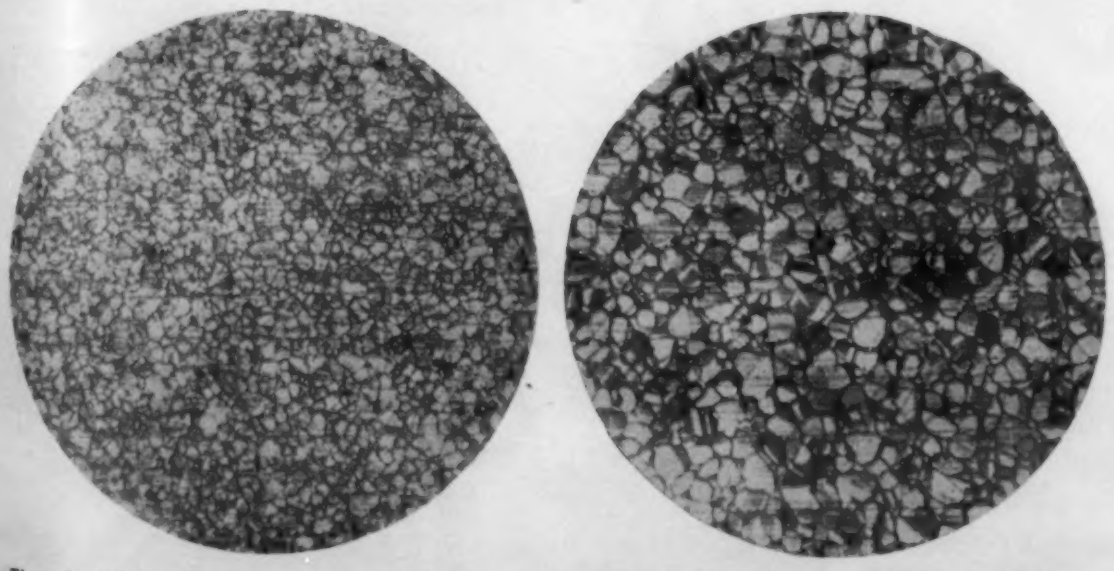
General Practice in Forging

Fortified with the raw material and the equipment thus far briefly described, the operations in producing brass forgings are generally as follows: The extruded material, of varying sizes, is cut into slugs of sizes to suit the forging to be made. These are usually sawed from the rod, though the small dimension ones are sometimes sheared to size. Extruded forging rod is seldom pickled before the forging operation. It comes from the extruder free from scale and with a clean surface.

The Operating Side of the Hammers for Making Brass and Copper Forgings at the Dallas Plant. Heating furnaces at the left of each operator.

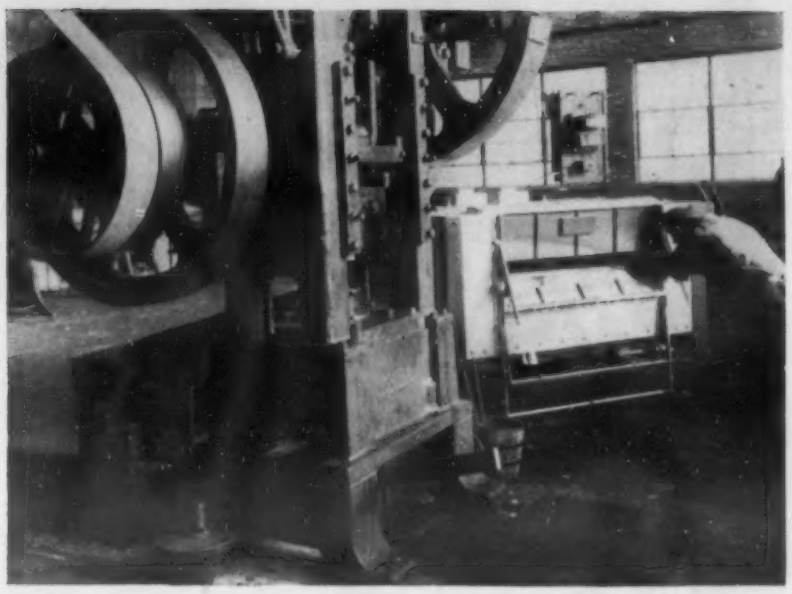
Slugs, thus prepared, are heated in the pre-heating furnaces, usually at 1400 to 1420 deg. F., and then forged in the presses or under hammers depending on the character and design of the product. When pressed forgings are made, only one is commonly produced at a time, though when the parts are small several are made at once. If the hammer is used, it is customary to make at one time from two to eight forgings in mul-

Figs. 5, 6 and 7. Structures of Extruded Brass Rods which Performed Satisfactorily in Forging. Magnification, 100 diameters.



Figs. 8 and 9. Structure of Extruded Brass Rods which Did Not Forge Properly and Cracked during Forging. Magnification, 100 diameters.

Fig. 10. Structure of the Front End of an Extruded Brass Rod which Forged Satisfactorily. Magnification, 100 diameters.



Close-Up of a Forging Press for Copper and Brass Forgings Showing Pyrometer Controlled Heating Furnace for Heating Slugs before Introduction into the Press.

tiple impression dies. One stroke in the press produces a forging, though this is not always the case; anywhere from three to eight or more blows are necessary under the hammer. Multiple dies or forgings are more common in hammer work than they are in press work.

There are many factors to be considered in determining whether or not a given forging should be made as a press or a hammer job. In general, the press is favored for forgings which involve a small draft. On forgings where a heavy draft in the order of 5 deg. is required, the hammer is favored.

There is a wide range of forgings which can be economically produced, either on a press or on a hammer, and general conditions in the operating shop would usually determine the selection of the type of equipment to be used in such cases.

Commercial forgings are produced in finished weights running from a fraction of an ounce up to 10 lb. The bulk of the brass forging business today is made up of parts ranging in weight from 2 oz to 5 lb. each.

Some Questions Answered

An interesting question regarding brass or copper forgings is—*"How large and how complex an article can be made?*

This is difficult to answer satisfactorily. One of the sales managers of the Revere company states that size and contour have considerable to do with the question of whether or not a part can be made as a forging. A small piece, weighing a fraction of a pound, may be extremely more difficult to forge because of its contour than one weighing several pounds with a contour more ideal for fabrication as a forging. This salesman states that, as far as he knows, forgings have been made by some companies running as high as 40 lb. each. On certain special jobs, certain steel forging manufacturers have produced brass and copper forgings in simple shapes in weights running up to several hundred pounds.

Another question which is of interest is—*Is it possible to gather up big bosses and still have a thin-walled web between them?*

This is also characterized as a rather difficult question to answer. The reply from the same source as that of the previous problem is about as follows: It is possible on any weight forging to have bosses. In order that the use of the word may be fully understood, the term means details on a forging or about the outside diameter that are heavier than the metal in between. If the details of the part itself and the boss are such that it can be made as a forging, the only element of doubt would be in the thickness of the web being in proper relationship with the weight and area of a whole piece. In other words, in a forging of one weight, it might be perfectly practicable to make the web as light as ⅛ in., while on another forging, due to different details, it might not be practical to go below ¼ in. on the webs.

Definite answers to both these and similar problems or questions can only be given when specific details for consideration are available. Even then problems are presented that only a try-out will definitely answer.

Heat Treatment

It is not the usual practice to heat treat the finished forgings. There are sometimes special cases when specifications call for a moderate annealing treatment for about 30 min. at low temperatures (600 deg. to 800 deg. F.) to relieve stresses, followed by air cooling. Whether forgings are made in presses or under hammers, the relative punishment to which the metal is subjected is a matter of dispute. In both cases it is severe—some insist it is more severe in the case of the press. But when the use to which the forgings are put is considered, the matter of stress relieving or alteration of structure by heat treatment is not regarded as vitally important.

Final preparation of the forgings varies in particular cases. Some are subjected to pickling before plating, or otherwise; some are tumbled to improve their appearance.

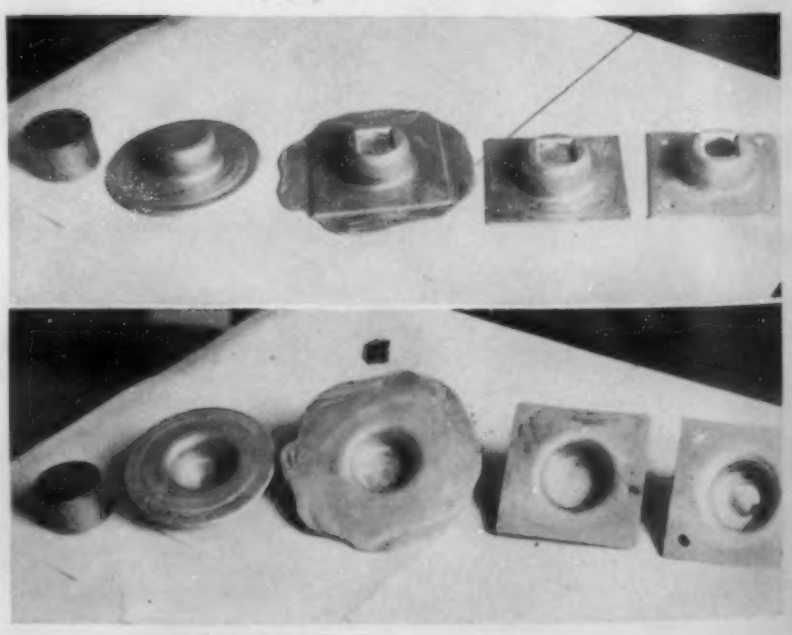
In the production of copper forgings, the practice herein outlined is in the main the same, except that hot-rolled copper rods are used. There are minor variations in temperatures and in other considerations.

Effect of Microstructure on the Product

To what extent do the variations in structure of the extruded brass rods affect the forging qualities of the metal? It is recognized that in the extrusion process the temperatures and the pressures vary as the metal is being extruded. Temperatures at the front end of the extruded rod will be considerably different from those in the subsequent portions of the rod. Pressures also vary during the extrusion. As a consequence the structure of the metal is different in different portions.

Photomicrographs (Figs. 5 to 10) represent various structures, all at 100 diameters, of extruded brass rods. Figs. 5, 6 and 7 are from a rod which was found, by

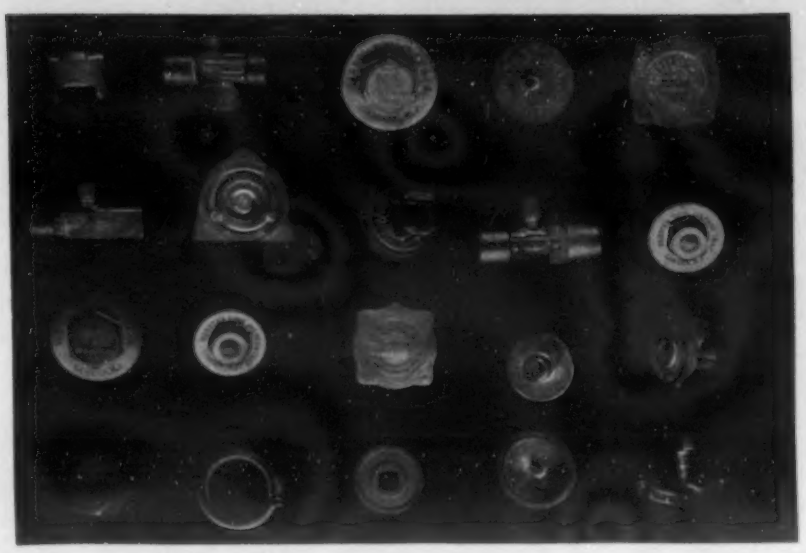
A Slug and the Appearance of the Pressed Brass Forging during Various Steps of the Process. (Top and Bottom Views of the Forged Material.)



the metallurgical department of the Dallas (Chicago) Division of the Revere company, to perform satisfactorily in forging. The material represented by Figs. 8 and 9 did not forge correctly but cracked while being forged. But Fig. 10 is the structure of a rod which forged very well and which was from the front end of an extruded rod. It can be seen that the structures vary in each case.

This subject has been discussed in Germany in two articles in *Zeitschrift für Metallkunde*.[1] A summary or condensed abstract of the opinions of these German authorities is as follows:

> In extruding the billet, the temperature should be about 1500 deg. F., or high as possible, and the container should be heated so as to maintain an even temperature. When, in the beginning of the operation, the rod which first comes out is either beta or alpha, or alpha and beta as to structure, it will be in needle form if the cooling is fast. There will be no transformation of grain because this metal is not strained, and as the operation continues the metal in the container will become more mechanically strained, while the outside of the billet is cooling very rapidly which is already transformed to alpha and beta structure. When this is finally pushed out of the die, a transformation occurs because of the highly strained metal and a structure, spheroidal in character, will be produced.
>
> Because the metal is in a very strained condition, recrystallization occurs with a mechanical crushing which is as follows: The beta part, in leaving the die, decomposes to alpha and beta in needle form; if the cooling is rapid, there is no twinning and no recrystallization of alpha. Then the alpha and beta undergo, in leaving the die, recrystallization; the structure is then in the spheroidized form and shows twinning. The beta part, or first few rods from the extrusion, receives the least pressure while the alpha and beta which have already been formed will get mechanically crushed by straining the metal and will recrystallize into the spheroidized structure.



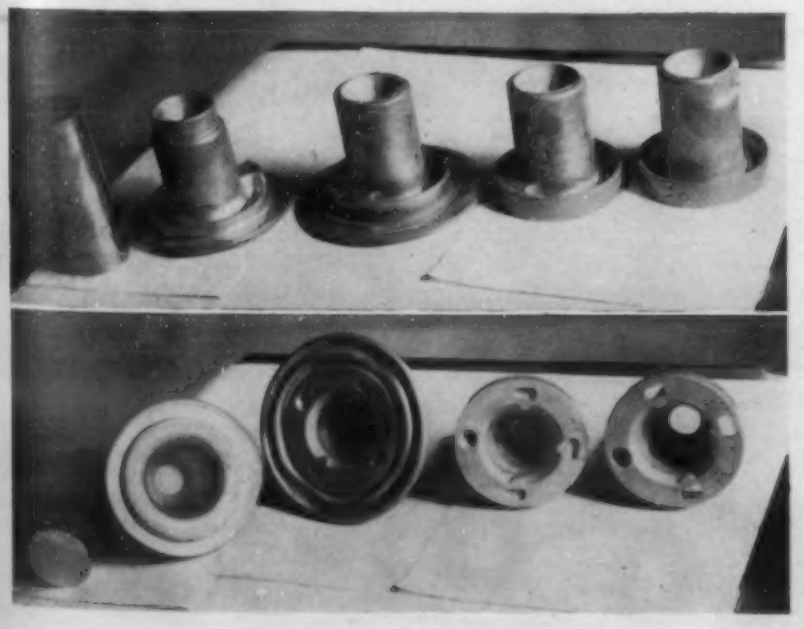
Miscellaneous Brass Forgings.

In further reference to this subject, introduced here because of its interest rather than its effect on users of brass forgings, it is suggested that there is no true connection between structure of extruded rods and forging properties because the extruded metal when forged is heated into a plastic range where working stresses are fully relieved. It is further suggested that, when cracking and hot shortness are encountered in forging, it is due to non-metallic inclusions, gas or contraction cavities or other casting imperfections in the billet being forged. Some work has been conducted for the past four years in an attempt to prove there was some relationship between the structure of the extruded rod and the forging qualities of that rod but to date no evidence has been developed to prove the contention that extruded structure has an important bearing on forging qualities of a material.

TABLE OF APPROXIMATE PHYSICAL PROPERTIES OF METALS CAPABLE OF BEING HOT FORGED

Name of Metal	Forging Qualities	Forging Temperature Deg. F.	Tensile Strength Lbs. Per Sq. In	Elong., Per Cent In 2 In.	Hardness, Annealed State Rockwell 60 kg. Load 1/16 Ball	Brinell 500 kg. Load 10 mm. Ball	Analysis
Copper, Electrolytic	Good	1400-1500	30,000	50%	40	35	Cu 99.9
Copper, Phosphorized	Good	1400-1500	32,000	50%	40	35	Cu 99.9
Copper, Silicon	Good	1400-1500	32,000	50%	40	35	Cu 99.7
Copper, Lake	Good	1400-1500	32,000	50%	40	35	Cu 99.9, Ag 7 oz. per ton
Copper, C & H Lake Special	Good	1400-1500	33,000	50%	40	35	Cu 99.9, Ag 11-13 oz. per ton
Copper, Arsenical	Good	1400-1500	33,000	50%	40	35	Cu 99.7
Copper, Cadmium	Good	1400-1500	37,000	50%	40	35	Cu 99, Cd 1
Gilding Metal	Good	1350-1450	33,000	50%	43	45	Cu 95, ZN 5
Muntz Metal	Excellent	1250-1350	45,000	45%	70	65	Cu 60, Zn 40
Roman or Tobin Bronze	Excellent	1250-1350	65,000	38%	85	80	Cu 60, Sn 0.75, Zn 39.25
Naval Brass	Excellent	1250-1350	65,000	38%	85	80	Cu 60, Pb 0.2, Sn 0.75, Zn 39.25
Manganese Bronze	Excellent	1250-1350	65,000	35%	85	80	Cu 57.50, Sn 0.75, Zn 41.25, Mn 0.05
Silicon Bronze (Herculoy Everdur, Olympic Bronze, PMG Metal, etc.)	Good	1350-1450	67,000	50%	85	80	Cu 96, Si 3-3.25, Sn 0.5, Zn 0.5

A 9½-lb. Slug and Steps in its Conversion into a Fairly Large Forging for a Refrigerator Part. (Top and Bottom Views.)



Other Copper-Base Forgings

This discussion has been confined to brass and copper forgings. But there are many other copper-base alloys which are capable of being forged and from which many valuable and useful products are possible. A detailed discussion of these alloys is not germane to this article, but the accompanying Table gives a comprehensive idea of these alloys, their forging qualities, their physical properties, their composition and other data.

[1] "Die Gefügeausbildung von Hartmessing Ms 58 nach verschiedener Wärmebehandlung" by Von P. Siebe and G. Elsner. *Zeitschrift für Metallkunde*, Vol. 22, April, 1930, pages 109-114.
"Die Gefügeausbildung in Hartmessing Ms 58" by Von R. Hinzmann and H. Flössner. *Zeitschrift für Metallkunde*, Vol. 22, April, 1930, pages 115-118.

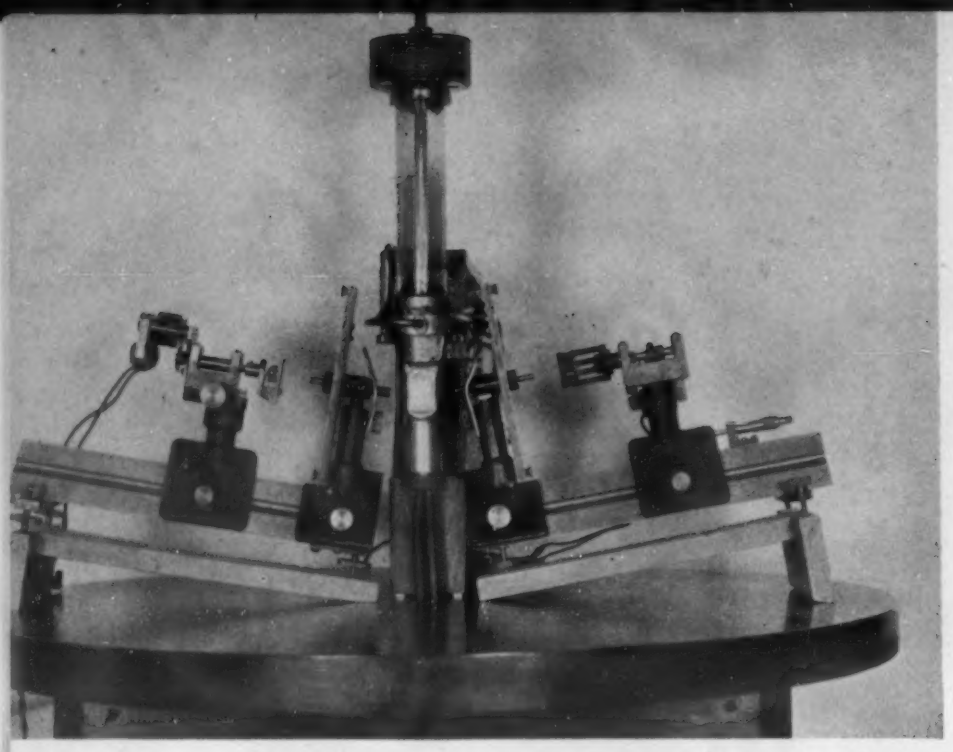


Fig. 1. X-Ray Tube and Cameras for Measuring Lattice Parameters of Metals.

Simplified Technique for Lattice Parameter Measurements

By JOHN T. NORTON

Associate Professor, Physics of Metals, Massachusetts Institute of Technology, Cambridge, Mass.

IN STUDYING the behavior of alloy systems, it is often important to know the composition of particular phases which may exist over a considerable composition range. This problem is frequently met in the determination of solid solubility, in age hardening, in the study of transformation in the solid state and in many other branches of physical metallurgy. A practical method for such a determination should have a reasonable degree of accuracy, should be independent of the presence of other phases and should be sufficiently simple in operation so that it could be carried out under the same general conditions as a microscopic examination.

It has been shown that the lattice parameter of a phase, such as a solid solution which is homogeneous over a composition range, is a simple function of the composition, and this appears to be an ideal method of obtaining the desired information. Unfortunately, the methods of parameter determination as used in the past have been rather difficult of application and have required a somewhat more specialized knowledge than was generally available. The practical metallurgist hesitated to use this slightly mysterious method. However, with the development of new equipment and the standardization of technique, it has become possible to make parameter measurements in a routine fashion without sacrifice of the accuracy necessary for good work.

The First Step

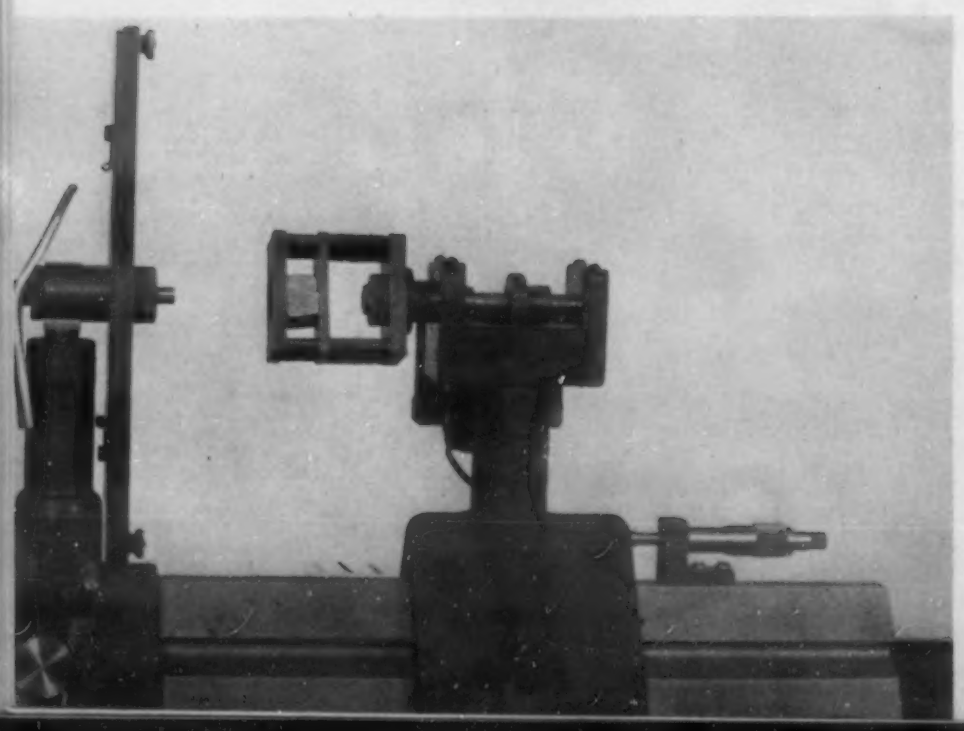
Lattice parameter measurements are particularly useful in the study of phases of variable composition. In order to investigate such a phase, the first step is to obtain the relation between parameter and composition. This is done by preparing several alloys in the homogeneous region and determining their chemical composition and parameter. The relation is so nearly linear that only a few points are necessary to determine the curve, and considerable extrapolation is possible. With this curve available, the lattice parameter of an alloy containing the phase in question will indicate the composition of the latter without regard to the presence of other phases. Under certain circumstances, lack of equilibrium conditions in the alloy has a disturbing effect which may be misleading, but such is true of most other methods of examination. The possibilities of this situation are well recognized and can be avoided.

X-ray studies of alloys have been carried out for a number of years in the X-ray metallography laboratory at M.I.T. and one of the principal objects has been to make the method available to those who have not particularly specialized in the theoretical phases of X-ray work. A great variety of apparatus has been tried and numerous simplifications have been found, so that now a relatively unskilled man can be taught to make accurate parameter measurements as easily as he can be taught to use the photomicrographic camera.

Experience has shown that X-rays of relatively long wave length such as are obtained from targets of copper, chromium, iron, and cobalt are particularly suited for the study of alloys. When these are combined with cameras of high resolving power which make use of the large angles of diffraction, a very simple unit results and good pictures are secured with short exposures. Such combinations are now generally used.

For general purposes the most satisfactory X-ray tube is the all-metal model of the "gas" or ion type. It is inexpensive to build, can stand lots of abuse, and the parts are easily and cheaply replaceable. It gives a very intense beam. Under proper circumstances it runs very steadily with unrectified current and requires almost no attention. Fig. 1 shows a tube of this type as described by Hägg.[1] It was constructed in the laboratory shop and has given such good results that two more have been built. The target is easily removable, permitting a rapid change from one target material to another. The windows are merely pieces of thin aluminum foil attached with stop-cock grease. The body of the tube is machined from a solid steel block and is cooled by copper tubing soldered to the outside. The insulator is a piece of pyrex glass tubing. The cathode is cooled by fins at the top and the cathode button is removable through the target opening so that

Fig. 2. Latest Model of "Back Reflection" Camera. Note the micrometer for adjusting the sample to film distance.



no seals or vacuum connections have to be disturbed. A tube of this type is very strongly recommended for metallurgical work.

The vacuum system is important in the operation of the X-ray tube. A simple and practical system, similar to that employed by Westgren in Stockholm, is employed. A five-gallon glass bottle acts as a vacuum reservoir and is evacuated by a rotary oil pump. This bottle serves as the fore vacuum for a simple single stage mercury condensation pump which is connected directly to the X-ray tube. Another small tube connects the bottle to the X-ray tube through an adjustable needle valve. By properly regulating this "leak," the pressure in the X-ray tube can be adjusted and maintained at the proper value. If the system is reasonably tight, the bottle needs pumping out only once in several days. With the tube in operation, the needle valve needs adjustment only about two or three times per day. The operation is so steady that any sort of an automatic control is quite unnecessary.

Fig. 3. Film of Pure Magnesium Taken with Camera of Fig. 2, using Iron Radiation. Note the scale printed on the film.

Fig. 2 shows the type of camera which has proved very practical for measuring changes in lattice parameter. It is a modification of a type described by Sachs[2] and this particular model is the result of a long process of evolution. The X-ray beam defined by a slit passes through a hole in the center of the film and falls normally on the surface of the specimen which is placed in a rotating holder. Either a solid or a powder specimen may be used. The reflected X-ray beams fall upon the stationary film which is clamped in a holder set at right angles to the primary beam. The specimen to film distance is regulated by a micrometer screw so that conditions can be exactly reproduced from one run to another. This camera has given consistently good results over a considerable period of use.

Making a Determination

The procedure of making a determination is somewhat as follows: The experimenter knows the approximate value of the parameter from the type of system being studied. From a chart he finds the proper target to use, the approximate position of the lines on the film and the proper position of the slit to obtain a sharp focus. He places the proper target in the X-ray tube and starts the pumping system. The sample is next prepared. If it is a solid specimen he grinds one face flat and polishes it as if for metallographic examination, stopping, however, after the No. 0 paper. The specimen is then etched fairly deeply to remove the effects of the cold work due to polishing. The specimen is now placed in the camera, the necessary adjustments are made and the film holder is loaded. By this time, the tube is evacuated and can be set in operation. The camera is aligned so that a strong beam falls on the sample and the film holder is clamped in place. The exposure requires from 30 min. to 1½ hr., depending upon the sample. When the exposure is complete, the film is taken to the dark room and a millimeter scale is printed upon it. This permits a reading of the line spacing and automatically corrects for film shrinkage. After development, the lines and the scale graduations both appear. If desired, the line spacing can be read from the wet film but it is usually dried and read on an illuminated screen. The line spacings are then applied to another chart and the lattice parameter is read off directly. Fig. 3 shows a film of pure magnesium obtained with this camera, while Fig. 4 shows a typical chart from which the parameter is read.

The proper use of charts simplifies the procedure tremendously by the elimination of lengthy calculations and are quite easily constructed to give the necessary precision. The X-ray camera is merely a device for measuring the angle at which the X-ray beam is deflected by its reaction with the sample. The charts are thus a graphical representation of the simple relation connecting this angle, expressed in terms of the geometry of the camera with the X-ray wavelength used and the lattice parameter. This relation is the well-known law of Bragg. The data required in preparing the charts can be found in a number of standard texts on X-rays.

For most work on alloys, one is chiefly interested in the change in composition as the result of some treatment and consequently, it is desired to measure a change in lattice parameter, the absolute magnitude being relatively unimportant. For some purposes, how-

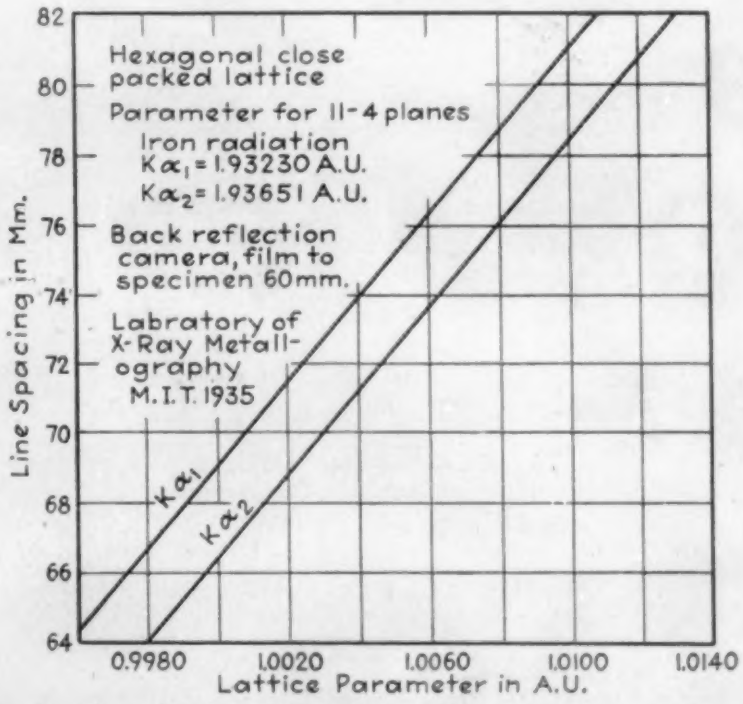


Fig. 4. Chart Used in Determining Lattice Parameters. This one is suitable for magnesium base alloys and iron radiation.

ever, absolute values are desired and in this case a camera of the type shown in Fig. 5 is employed. This camera gives high resolution and the lines are in sharp focus over a greater range of angles than in the model previously described. By proper correction[3] for the camera errors, it can be made an absolute instrument to give precise values. The condition of samples in practical use seldom warrants the added precision obtainable with this type of camera.

Typical Application of the Method

The determination of the solid solubility of copper in iron[4] is a typical example of the application of this method. The first step was the preparation of a series of alloys of the pure metals covering the suspected

solubility range. These samples were very carefully homogenized at just below the eutectoid temperature, which was the temperature of maximum solubility and quenched to retain all of the copper. Parameter measurements were made on all the samples and the values plotted against composition as determined by chemical analyses. All of the points with the exception of the two highest copper samples lie on a straight line as can be seen in Fig. 6. Obviously these last alloys are beyond the maximum solubility and are in the two-phase field since here the parameter does not change with composition. A horizontal line through these points, extended to meet the sloping curve, will intersect at the composition corresponding to the maximum solubility which is 1.4 per cent copper by weight.

In order to follow the solubility limit as it changes with temperature, the 2 per cent alloy was homogenized at a series of lower temperatures and the parameter measured in each case. The parameter of the

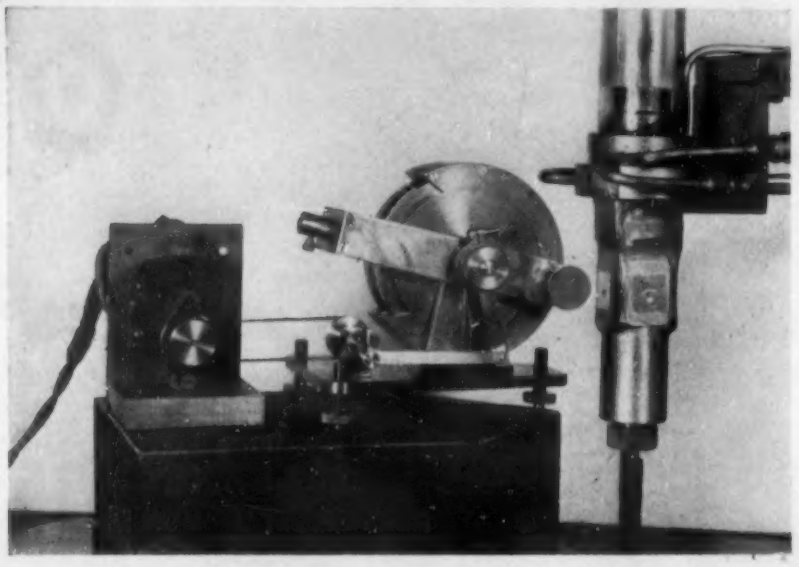


Fig. 5. X-Ray Camera of the Symmetrical Focussing Type for Absolute Measurement of Lattice Parameters of Metals.

saturated solution was found to decrease with decreasing temperatures as shown in Table II, and by applying these values to the parameter composition curve, it is evident that the copper content decreases with decreasing temperature. Fig. 7 shows the solubility curve

TABLE I.—Iron-Copper System
Lattice Parameter vs. Composition
Samples Quenched from 860 deg. C.

Wt. % Cu.	Lattice Parameter, A. U.
0.00	2.8607
0.25	2.8609
0.31	2.8610
0.44	2.8613
0.75	2.8617
2.06	2.8626
3.39	2.8625

TABLE II.—Sample Containing 2.06 Percent Cu. by Wt.
Quenched from Temp. Indicated

Temp. Deg. C.	Lattice Parameter	Cu. in Solution, %
850	2.8626	1.30
835	2.8623	1.12
810	2.8620	0.92
785	2.8618	0.80
760	2.8614	0.56
700	2.8611	0.34
600	2.8610	0.31
500	2.8611	0.34

resulting from this data. Such a curve accounts for the age hardening of this alloy.

In this case, the total change in parameter from maximum to minimum solubility is only about 0.0013 A.U. and the error in measurement is about 0.0002 A.U. so that the accuracy in measuring composition is not high. With other systems, the change may be very much greater with consequent increase in accuracy of results.

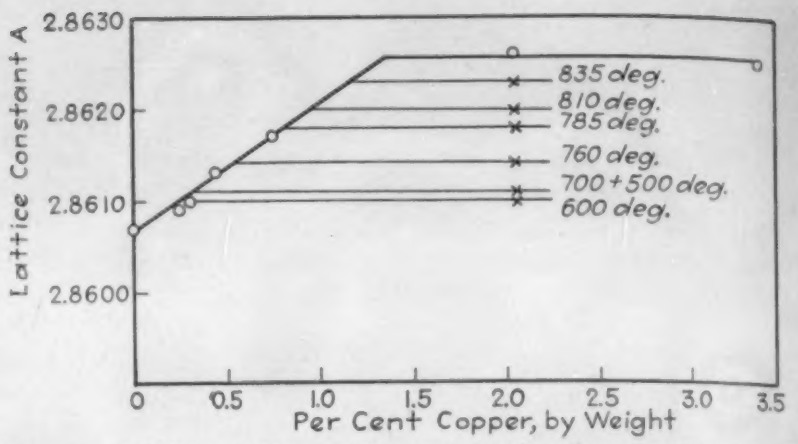


Fig. 6. Relation of Composition and Lattice Parameter for Iron-Rich Solid Solution.

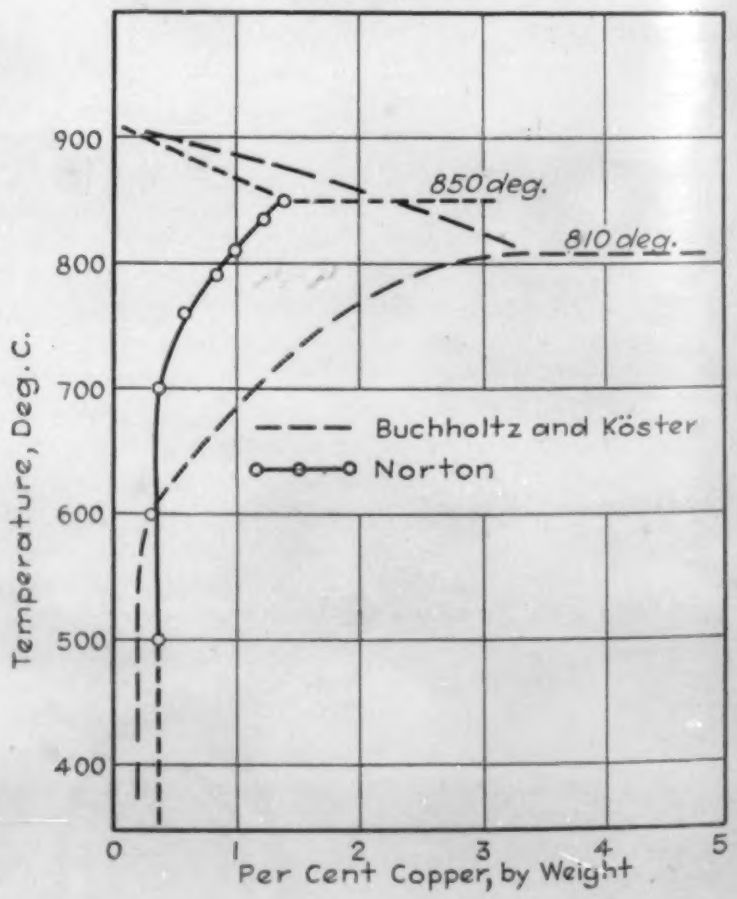
Application and Interpretation Realized

If X-ray measurements of lattice parameters are to be included among the standard metallographic tools, they must be capable of simple application and interpretation by the metallurgist of ordinary training. Experience during the past two years with the apparatus described above has shown that this ideal condition has been closely attained. A number of undergraduate and graduate students with no particular X-ray experience have been taught to use the method in research problems with excellent results. They were sufficiently familiar with the structure of metals so that the results could be interpreted in an intelligent manner, but their training in the X-ray method itself was no more extensive than in the case of the photomicrographic method. Their X-ray pictures were quite as good as their photomicrographs. This experience has shown that the method can be carried out in a practical way and it is certain that no one will deny the importance of the X-ray information, once it has been properly obtained.

References

[1] G. Hägg. *Review of Scientific Instruments*, vol. 5, 1934, page 115.
[2] G. Sachs & J. Weerts. *Zeitschrift für Physik*, vol. 60, 1930, page 481.
[3] M. U. Cohen. *Review of Scientific Instruments*, vol. 6, 1935, page 68.
[4] Norton. A.I.M.E. *Tech. Paper* No. 586, 1935.

Fig. 7. Solubility of Copper in Iron.



Temper-Hardening of Commercial Nickel-Coppers Containing Phosphorus

By E. C. ROLLASON, M.Sc. and
T. G. BAMFORD, M.Sc., A.I.C.

County Technical College, Wednesbury, England

THE authors investigate the temper-hardening of three commercial nickel-coppers containing phosphorus. Marked increase of hardness, elastic limit, and tensile strength occur upon tempering a quenched sample containing 0.11 per cent phosphorus and 1.73 per cent nickel.

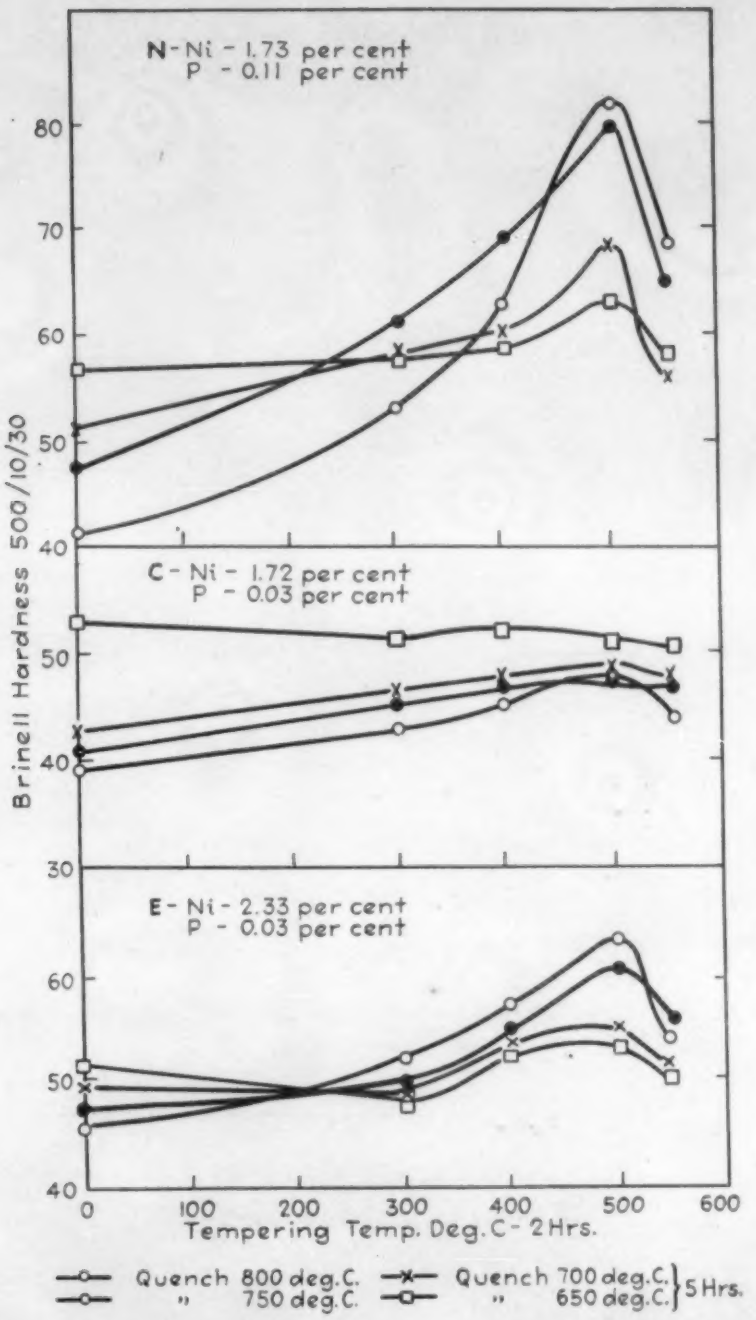
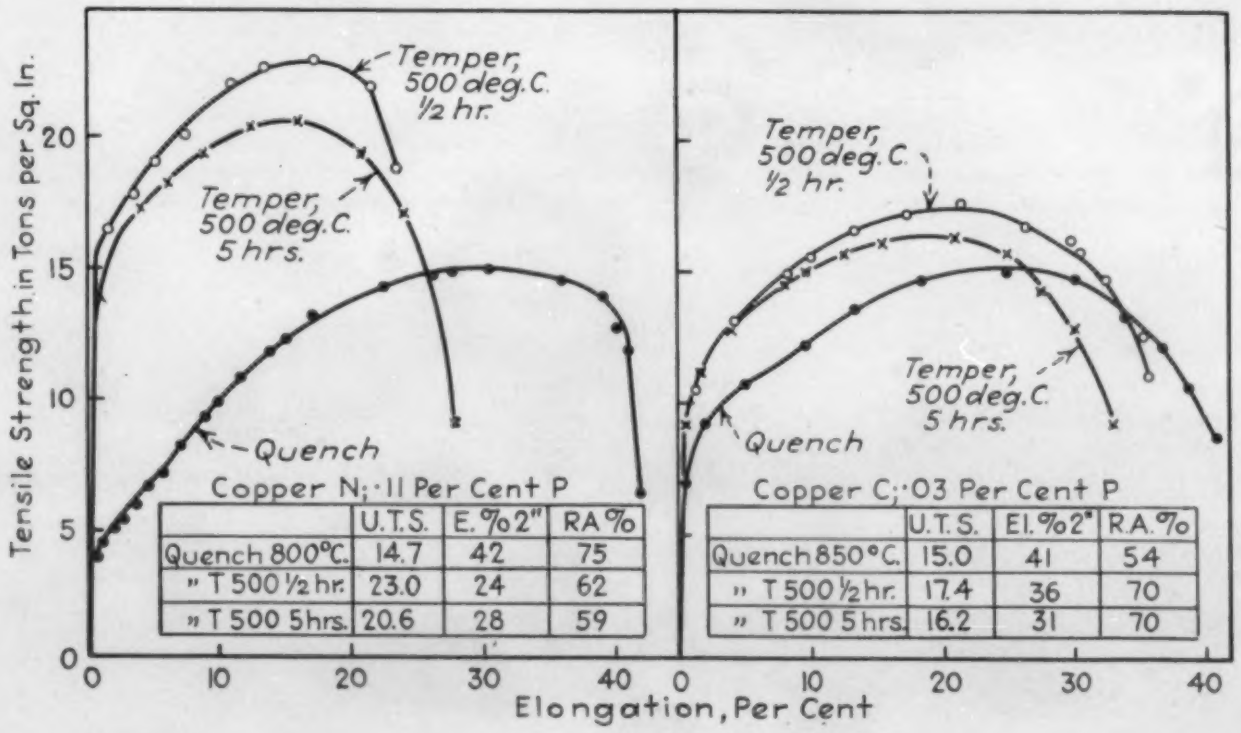

N - Ni - 1.73 per cent
P - 0.11 per cent
C - Ni - 1.72 per cent
P - 0.03 per cent
E - Ni - 2.33 per cent
P - 0.03 per cent
Brinell Hardness 500/10/30
Tempering Temp. Deg. C - 2 Hrs.
Quench 800 deg. C. 750 deg. C.
Quench 700 deg. C. 650 deg. C.
5 Hrs.

Fig. 1. Hardness of Quenched and Tempered Nickel-Copper.

CERTAIN TESTS upon deoxidised nickel-copper published by one of the authors[1], revealed an increase of hardness and tensile strength after annealing at 750 deg. C. upwards, while deoxidised nickel-free coppers showed normal softening under such treatment. The present investigation was designed to elucidate the significance of this phenomenon.

The experiments are mainly confined to the commercial coppers in Table I, although work on alloys made in the laboratory is in progress.


Temper, 500 deg. C. ½ hr.
Temper, 500 deg. C. 5 hrs.
Quench
Copper N; ·11 Per Cent P
Temper, 500 deg. C. ½ hr.
Temper, 500 deg. C. 5 hrs.
Quench
Copper C; ·03 Per Cent P
Tensile Strength in Tons per Sq. In.
Elongation, Per Cent

	U.T.S.	E. %2"	RA %
Quench 800°C.	14.7	42	75
" T 500 ½ hr.	23.0	24	62
" T 500 5 hrs.	20.6	28	59

	U.T.S.	El. %2"	R.A. %
Quench 850°C.	15.0	41	54
" T 500 ½ hr.	17.4	36	70
" T 500 5 hrs.	16.2	31	70

Fig. 2. Effect of Heat Treatment on the Stress-Elongation Curves of 1.7 Per Cent Nickel-Copper.

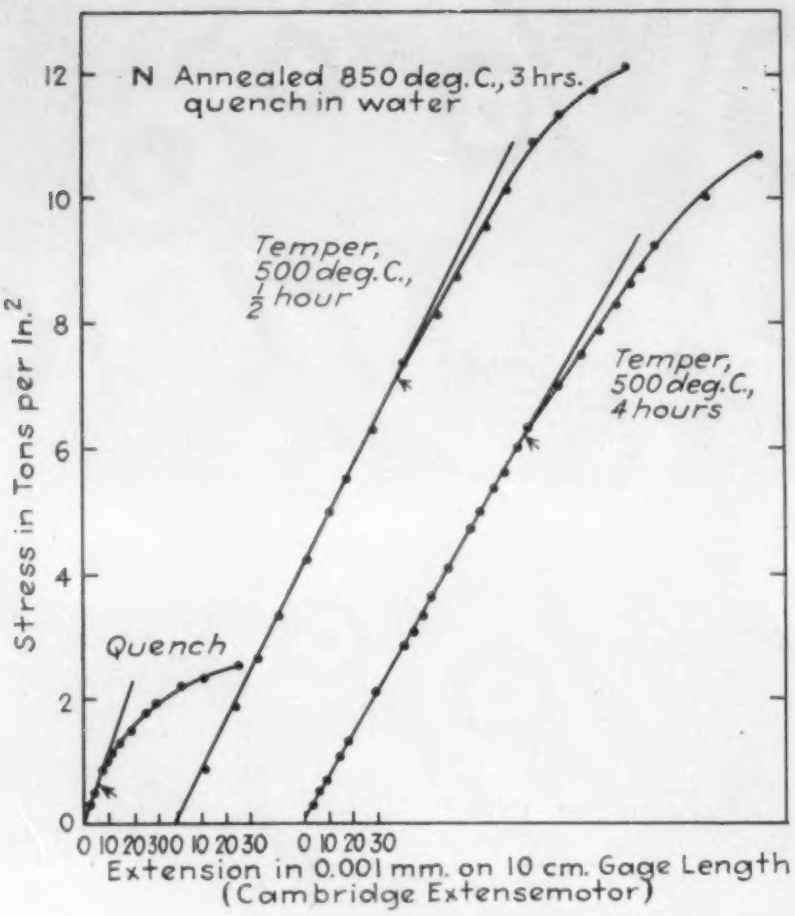

N Annealed 850 deg. C., 3 hrs. quench in water
Temper, 500 deg. C., ½ hour
Temper, 500 deg. C., 4 hours
Quench
Stress in Tons per In.²
0 2 4 6 8 10 12
0 10 20 30 0 10 20 30 0 10 20 30
Extension in 0.001 mm. on 10 cm. Gage Length
(Cambridge Extensemotor)

Fig. 3. Effect of Tempering on the Elastic Limit of Nickel-Copper Quenched from 850 deg. C.

TABLE I—Composition of the Coppers

Sample	Ni	P	Fe	Mn	Sn	Pb	As	Loss in H
C	1.72	0.03	trace		nil	trace	trace	0.010
N	1.73	0.11	0.01	trace	nil	trace to 0.01	nil	0.004
E	2.33	0.03	0.03					

Some of these coppers are patented.

Coppers C and E were prepared in the normal manner as described in a previous paper.[2] Some difficulty was experienced with the higher phosphorus copper N. When cast in a split mold, the fray caused pulling cracks during the rolling operation. Using a 3-inch cannon mold, successful results were obtained. Preliminary experiments by heating small sections of these coppers in air and in hydrogen to temperatures above 700 deg. C showed that in both cases the rate of cooling influenced the final hardness.

TABLE II—The Effect of Rate of Cooling on the Brinell Hardness after Annealing at 850 deg. C for 1½ Hrs.

			Brinnell Hardness, 500/10/30		
	Ni. %	P %	Quenched in water	Air cooled	Furnace cooled
C	1.72	0.03	39	41	45
N	1.73	0.11	37	57	67
E	2.33	0.03	39	41	59

Typical results are shown in Table II. In all these experiments with alloys cooled from 850 deg. C., the slowest rate of cooling produced the greatest hardness. These results at once suggest temper hardening phenomena and therefore the alloys were subjected to annealing treatment followed by quenching and tempering.

Effect of Heat Treatment on the Mechanical Properties

The variations of hardness under diverse quenching and tempering treatments are shown in Fig. 1. Maxima points develop after tempering at 500 deg. C. and the specimens quenched from the highest temperature of 800 deg. C. develop the greatest increment of hardness when tempered at this temperature.

Of the two specimens, C and N, with equal nickel content—the one with high phosphorus reveals very much the more marked temper hardening properties

(Continued on page 349)

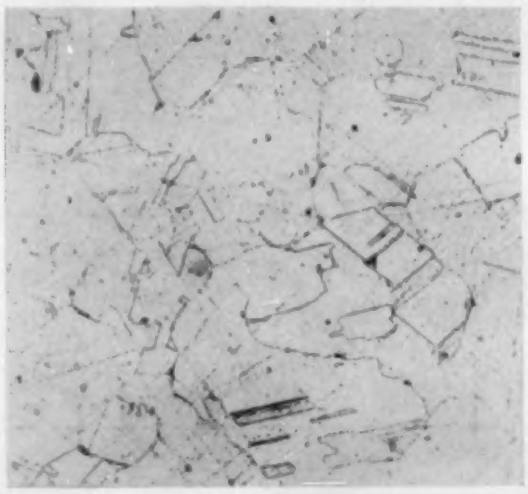


Fig. 4. Phosphorus-Nickel-Copper (Ni 1.73%, P 0.11%) 5 hr. at 750 deg. C. Quenched in Water. Brinell 44. Magnification 200 diameters. Etched in ammonium persulphate.

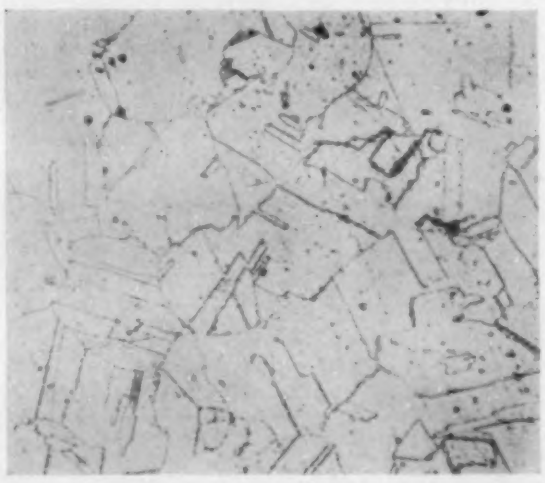


Fig. 5. Same as Fig. 4, but Tempered at 500 deg. C. for 2 hr. Brinell 81. Magnification, 200 diameters. Etched in ammonium persulphate.

Fig. 6. P-Ni-Cu (Ni 3.88%, P 0.50%). Heated 1 hr. at 850 deg. C., slowly cooled. Bri. 89. Mag. 500 dia. Small grains, dispersed P constituent. Am. persulphate etch.

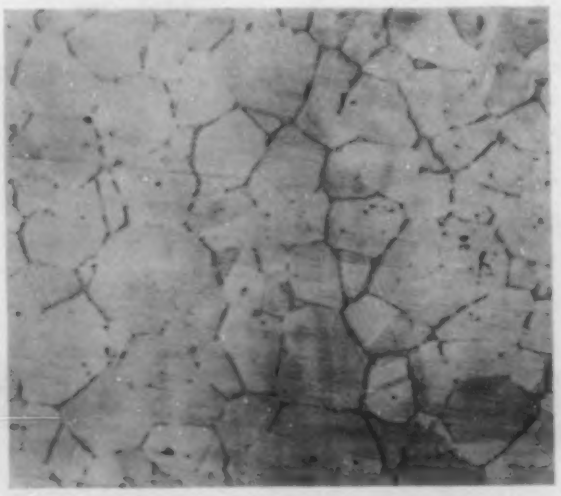


Fig. 7. Phosphorus-Nickel-Copper (Ni 2.17%, P. O. 44%. Heated 1 hr. at 850 deg. C., quenched. Brinell 54. Magnification, 100 diameters. Etched in ammonium persulphate.

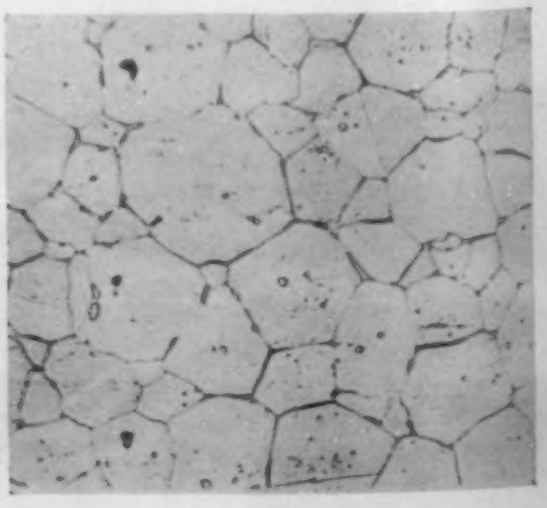


Fig. 8. Same as Fig. 7. Heated 1 hr. at 850 deg. C., slowly cooled. Brinell 114. Magnification, 100 diameters. Etched more readily in ammonium persulphate than Fig. 7.

Trends in Stainless Steel Production

By E. F. CONE

BECAUSE OF THE GROWTH and importance of such a new industry as the stainless steels, some facts regarding the trend of the production of these steels are keenly watched for. But the obtaining of reliable data from producing companies is by no means a simple task. There are some who decline for various reasons to furnish the information, no matter how strict the confidence involved.

About three years ago, late in 1932, the author attempted a survey of this industry, the result of which was published in *The Iron Age*, Feb. 16, 1933. That survey, obtained by circularizing practically all of the then producers, did not claim to represent the total industry. The steels included in the survey were the corrosion and heat resisting alloys, generally recognized as the high chromium and chromium-nickel steels, including those with other alloying additions made for special purposes. The survey was not meant to include the 4 to 7 per cent chromium type, with or without tungsten or molybdenum.

Reliable Statistics Valuable

Assured by many interested metallurgists that reliable statistics which reveal the trend of an industry are valuable, an attempt has been made to bring up to date the data published in 1933. The results of this effort are published in this brief article.

It has been possible to obtain authoritative statistics from most of the same companies which cooperated in the first survey—they are so nearly the same that the results are comparable. These include six of the largest producers of ingots and several of the foundries which produce most of the castings. Because of the helpful cooperation of these companies, the bringing-up to date of this analysis has been possible. It should be understood, however, that no claim is made that this survey represents anything more than a reliable presentation of the trend in the demand for these highly important steels.

In the first survey, published in 1933, the data covered production for the years 1929, 1930 and 1931, with estimated figures for 1932. The present compilation gives the data for 1932, 1933 and 1934. These compilations have been assembled in a table covering the six years, 1929 to 1934, inclusive. Only the totals

Table of Production of Stainless Steels by a Group of American Producers—Gross Tons

Year	Ingots	Castings
1929	39,287	2,949
1930	44,156	3,015
1931	24,670	2,157
1932	22,600	1,136
1933	59,393	1,665
1934	74,336	1,786
Totals	264,442	12,708

are given in this survey. A breakdown into certain types of the stainless steels was not possible in this latter survey because one or two large companies reported only their total production.

Decided Increase in Ingot Output

A study of these statistics reveals that there has been a decided upward surge in the demand for stainless steel products rolled from ingots—particularly since the low point of the depression in 1932. The 1934 output of ingots by the companies involved in this survey was 74,336 gross tons as compared with 22,600 tons in 1932. The peak previous to the depression was the 44,156 tons made in 1930. Thus the 1934 figure is about 230 per cent larger than the low point in 1932 and about 42 per cent larger than the previous peak in 1930.

This is a rather remarkable expansion in the face of a serious industrial depression. In fact the depression has apparently had little retarding effect on the demand for the stainless steels though the expansion might have grown to much larger proportions, had there been no business set-back.

Expansion in demand for castings has by no means been of the same proportions as for rolled and finished products, as judged by the data here presented. According to these figures the 1786 gross tons produced in 1934 by the companies involved in this survey is only 57 per cent larger than the 1,136 tons made in the depression year of 1932. On the other hand the 1934 production is about 40 per cent less than the peak output of 3,015 in 1930. While this disparity between castings and ingots cannot be accounted for satisfactorily, it is perhaps partly due to the fact that the whole steel casting industry has been harder hit than some other branches of the iron and steel industry.

Some Trends in Types

While the data here presented do not afford a complete breakdown of the ingot production as to types, a summary of those companies which did furnish such figures is of interest. An analysis on this basis results as follows:

Stainless Steel Output of a Group of Companies by Types—Gross Tons

Type	1932	1933	1934	Total
18 and 8	3,878	9,674	10,342	23,894
12 to 14% Cr (approx.)	580	1,695	3,188	5,463
16 to 18% Cr (approx.)	2,878	3,709	4,277	10,864
All other types	4,797	24,469	32,166	61,432

It is evident that the 18 and 8 type maintains relatively its popular appeal. At 23,894 tons for the three years, it is about 23.5 per cent of the total of 101,653 tons reported. The sharp gain in the "All other types" classification at 61,432 tons for the three years, or 60 per cent of the total, possibly is a measure of the greater use of such steels in high temperature applications.

Output of Some Licensees

Of general interest in connection with this subject is information furnished by the American Stainless Steel Co. of Pittsburgh. It states that the approximate total production, by its licensees, of "genuine stainless steel" under its patents is as follows in net tons:

1929	10,900
1930	8,500
1931	5,100
1932	3,600
1933	5,450
1934	6,625

It is to be understood that "these tonnages do not include other corrosion resisting materials such as 18 and 8 chrome-nickel alloys."

Of similar interest is information furnished by the Chemical Foundations, Inc., of New York, as to the

(Continued on page 349)

THE MERCUROUS NITRATE TEST

BY H. C. JENNISON

Technical Manager, the American Brass Co.

"A handsaw is a good tool, but not to shave with."

The misuse of tests is one of the most exasperating things the metallurgist must deal with. It is harmful and expensive alike to producer and consumer. It can only be averted by a patient campaign of education. Too often the producer fails to stand up on his hind legs and tell the purchasing agent of an important customer that his insistence on a test that sounds as though it should give useful engineering information but actually gives misinformation is an expensive pastime. Rather than offend the customer the producer is prone to keep silent and get out of the situation the best way he can.

In such cases publicity is a good way to handle the problem, for if a denial that a given test method has engineering value is published, it throws the burden of proof on those who advocate it. When they find they are unable to supply such proof, the situation will clear up.

We shall be glad to publish evidence as to other cases where tests that are valueless, or worse, are imposed upon industry.—H. W. G.

THE MERCUROUS NITRATE TEST has been included in specifications for a number of years. Very little, if anything, has been written about the correct and best method for applying this test, and its limitations—hence this article.

The first description in this country of the mercurous nitrate test, as applied to copper alloys was probably obtained from the May, 1914, Lecture of the British Institute of Metals, which lecture was presented by Heyn, and appears in Volume XII of the *Journal* of the Institute.

The test consists of immersing a specimen for a definite number of minutes in an aqueous solution of mercurous nitrate which has been prepared according to specifications. This procedure enables one to determine if the tensile stresses in the surface of the sample are of high magnitude. If such stresses are high, the article may crack. If the stresses are not sufficiently high or are in compression, cracking will not occur. The mercurous nitrate test has been made a part of most copper alloy specifications in order to make sure that the tensile stresses have been properly relieved in rods, wire, sheets, tubes, shapes, etc., before the material is shipped.

Various Specifications

This test forms a part of the American Society for Testing Materials specification—B21-29,—which covers naval brass rods for structural purposes, and is as follows:

> A 9-in. length of the test specimen shall stand, without cracking, an immersion for 15 min. in an aqueous mercurous nitrate solution containing 100 g. of mercurous nitrate and 13 ml. of HNO_3 (sp. gr. 1.42) per liter of solution. Bars which have been properly straightened or sprung will have internal stresses so broken up as not to be in danger of splitting or cracking. The mercurous nitrate test is designed to determine whether the internal stresses have been properly broken up and rendered safe.

Navy Department specifications—46B6g—for naval brass rods, etc., carry this test which reads in detail as follows:

> A 6-in. test length of the material shall be immersed for 10 min. in a mercurous nitrate solution of the following proportions: 100 grams mercurous nitrate and 13 cu. cm. of 1.42 specific gravity nitric acid per liter. Upon removal of the sample from the solution, the appearance of cracks in the material shall be cause for rejection.

The U. S. Army Ordnance department uses the mercurous nitrate test which appears in their metal specification No. 57-162 covering naval brass rods, etc. The details of this test as given in the specification are as follows:

> Strain Test: Specimens of material shall withstand immersion for 15 min. without cracking in an aqueous solution containing 100 grams of mercurous nitrate and 13 c.c. of nitric acid (specific gravity, 1.42) per liter.

The above will illustrate the manner in which the mercurous nitrate test is correctly used in recognized standard specifications. In every case it is a qualitative test and not quantitative. If the material cracks within the specified time, it is rejected. If it does not crack within this period, the material is acceptable. The greatest length of time of immersion is 15 min.

Not a Quantitative Test

The mercurous nitrate test is not a quantitative test, that is, it cannot be used for predicting the life or behavior of material under service conditions, and organizations familiar with the details do not consider it as such. However, certain engineers not familiar with the details are attempting to use it quantitatively. This is a grave mistake because the test was never intended for quantitative work and can never be properly used for this purpose.

To illustrate—an engineer said to the writer one time that he thought one piece of brass was better than another because a drawn shell from one cracked in mercurous nitrate in 10 sec. while a drawn shell from another piece of brass cracked in 14 sec. This attitude is just ridiculous because the surface condition of one sample might have been different from another, to say nothing about other possible details.

Others are attempting to make the test quantitative by allowing finished articles to remain in mercurous nitrate several hours and in this way attempt to determine if one article is better than other.

Copper alloys are very rapidly disintegrated by mercury. Some copper alloys resist mercury slightly better than others but none of them is suitable for use in mercury or solutions of mercury. The behavior of an alloy during long immersion in mercurous nitrate does not in any way predict its behavior in the field, and well-informed engineers are familiar with this fact.

When stresses are not properly removed during the manufacturing operations, some of the copper alloys may season crack when exposed to the atmosphere or certain types of corrosion. The mercurous nitrate test, as included in specifications above, is not even an accelerated laboratory season cracking test. It simply indicates if there are high stresses in the material and the material may or may not season crack in the field.

Material which does not crack in mercurous nitrate may be stressed in a testing machine to high values and mercurous nitrate applied, and the specimen will immediately crack, which shows that it makes no difference whether the stresses are the result of improper manufacturing operations or the result of improper stressing in the laboratory. Mercurous nitrate will cause the metal to crack when the stresses are of sufficient magnitude regardless of the source of such stresses. These same conditions hold true in the field. When material is overstressed, it may season crack whereas, if it were properly used, would not season crack in the field.

Some Attempted Quantitative Uses

Some engineers are trying to use the mercurous nitrate test quantitatively by placing certain devices under tension and then immersing the various articles in mercurous nitrate, attempting to apply the same tension in every case, and if one article cracks before another under these conditions, they are interpreting the results as indicating one is better than the other.

Some of the articles being incorrectly tested in this manner are designed to resist stresses and atmospheric corrosion in the field and they do not come in contact with mercury in service. When such articles contain 80 per cent or more of copper, they do not fail by season cracking or corrosion under conditions of atmospheric exposure.

When one uses the mercurous nitrate test quantitatively, the results are not only in error but very much misleading. Various devices which are being immersed in mercurous nitrate for unusually long times are really manufactured for resisting atmospheric corrosion under service conditions and not to resist the long time action of mercurous nitrate which is extremely corrosive and destructive to all copper alloys.

Everyone agrees that a service test is the most valuable type one can apply. There never has been a laboratory accelerated test devised which is equal to a service test. It is difficult to understand why engineers are attempting to evaluate different alloys by their relative behavior in mercurous nitrate for long periods. Conclusions derived from such tests are without value for predicting the behavior of alloys of high copper content under service conditions of atmospheric exposure.

(Continued from page 346)

lthough curve E shows that, by increasing the nickel content to 2.33 per cent without raising the phosphorus, the temper hardening is intensified.

Hanson and his collaborators[3] show that in pure copper the solubility of phosphorus is approximately 0.5 per cent at 282 deg. and increases with rising temperature and with such nickel-free copper, even at 0.69 per cent phosphorus, only slight temper hardening occurs. We are not aware that with nickel it is possible to develop this property in copper and it would appear that it is due to the combined influence of the phosphorus and nickel that the property is found in these commercial coppers.

An important effect of the tempering treatment on the tensile properties is illustrated in Figs. 2 and 3. While the ultimate tensile stress of the phosphorus-nickel-copper is increased from 14.7 to 23 tons per sq. in., it is in the elastic limit that an exceptional increase takes place. The values are raised from 0.8 tons per sq. in. for the quenched specimen to some 7 tons per sq. in. after tempering at 500 deg. C. for half an hour.

Microstructure

The microstructures were normal, little difference being detected between quenched and tempered specimens. In laboratory-made samples containing higher phosphorus content, a segregate was observable more definitely in tempered than in straight quenched specimens. This is shown in photomicrographs, Figs. 4 to 9.

The author's thanks are due to the Staffordshire Education Committee for providing facilities and to the Elliotts Metal Co., Ltd. for supplying the coppers.

References

[1] *Journal*, Inst. of Metals, XXXIII 1925, 1, p. 167.
[2] *Journal*, Inst. of Metals, XLIX 1932, 2 p., 238.
[3] *Journal*, Inst. of Metals, XLIII 1930, 1 p 41.

(Continued from page 347)

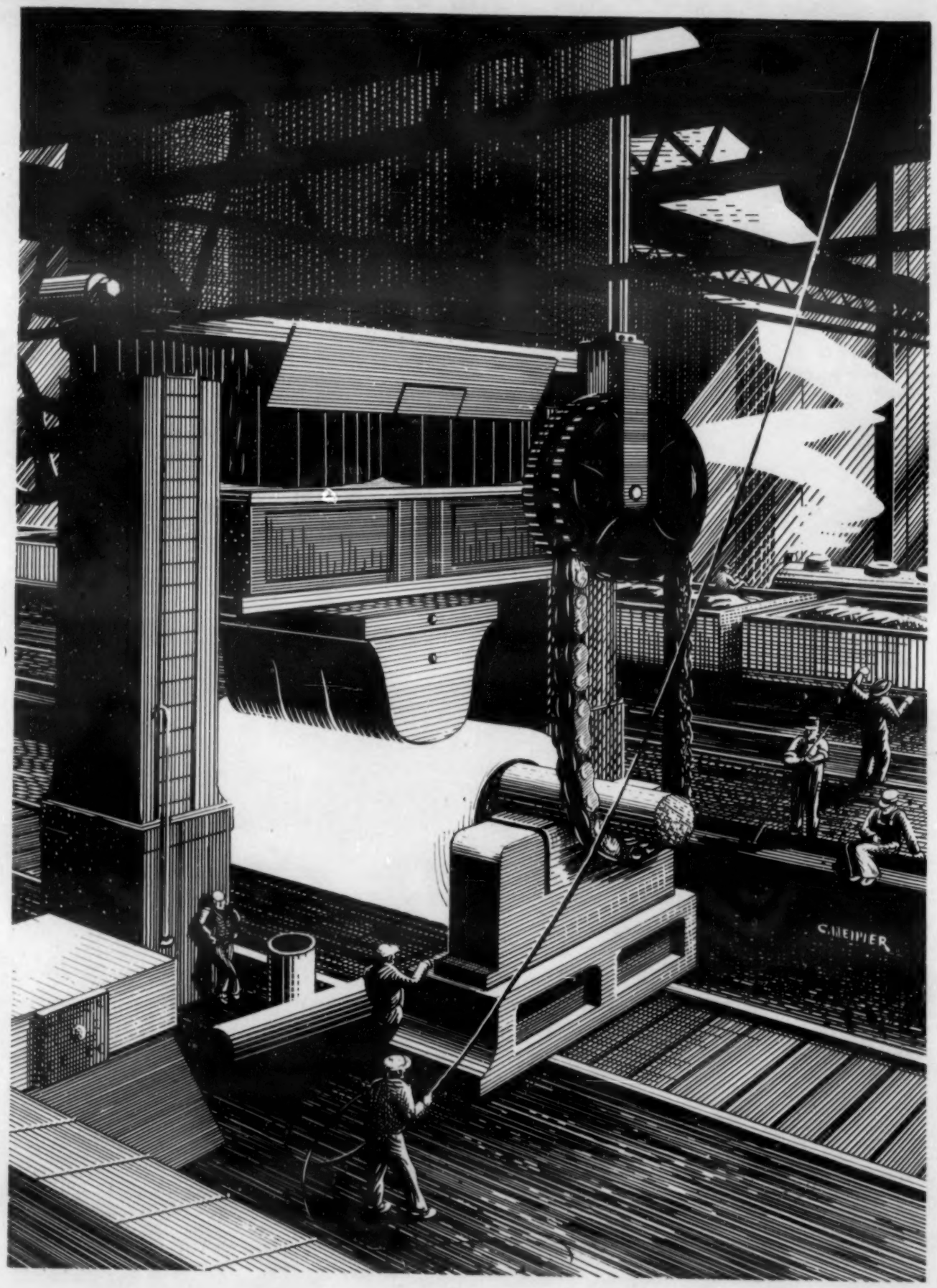
output of chromium-nickel alloy steels (stainless steels) covered by the Strauss patents Nos. 1,316,817 and 1,339,378. The data are as follows in net tons:

Period	Licensed Ingot Output	Licensed Casting Output	Totals
July 1 to Dec. 31, 1934	13,880	554	14,434
Jan. 1 to June 30, 1935	20,165	667	20,832
Totals for 1 year	34,045	1,221	35,266

Some Reflections

Perhaps an apology is due the reader for the incompleteness of the presentation of this subject. But the vital interest in an accurate and unbiased analysis has prompted this attempt. The incompleteness is not the fault of the author. Even the American Iron and Steel Institute cannot obtain complete data as to stainless steel ingots and particularly as to castings. It is the contention of the Alloy Casting Association that any publication of the trend in stainless steel casting production is detrimental to its interests. Hence its refusal, perhaps justified, to furnish any data to any organization.

The whole question is tied up with the value of such data to the public. There is intrinsic merit in statistics when accurate and properly handled. They do show definite and important trends. It is generally known that there is an upward trend in the stainless steel industry. An accurate presentation of the facts is better than mere guesses or unsubstantial rumors.



FORGING—FROM A DRAWING BY CHARLES PERRY WEIMER

Forging Furnaces at the Ford Plant

By J. B. NEALEY

American Gas Association, New York.

Front Radius Rod Furnace.

IN reading this interesting article, it should not be forgotten that the situation at the Ford plant is a special one. Just as the adoption of electricity for heating for forging was due to the availability of surplus energy, so was that of blast furnace gas due to its availability as surplus. Were the fuels to be purchased outside one would expect oil to figure prominently in the list, and, with the development of some of the newer kinks in electric heating for forging, electricity also might again figure. We very much doubt if the Ford plant is "standardizing" on any one fuel, but believe that instead it intentionally plans to be free to shift to meet changing economic conditions. Unless similar conditions hold there, another plant might be ill advised blindly to follow a Ford choice of fuel. The operating methods described are, of course, applicable in many ways to any fuel, so that the article is highly valuable, even though some of the implications call for comment.—H. W. G.

ONE OF THE OUTSTANDING characteristics of that phase of industry that has to do with the heating of metals, either for forming them or for normalizing the grain structure, is still the great variety which exists in furnace design and in methods of firing. In the Ford Motor Co.'s plant, however, standardization in these metallurgical items is progressing, although at present far from complete, as is the case elsewhere.

Among several hundred furnaces at Dearborn that now employ gas for fuel were about 50 that until recently used electrical energy. This was surplus energy generated in Ford's own power plant. By removing the heating elements and substituting gas burners, these furnaces were changed over to gas firing.

Furnaces Located in Long Rows

The furnaces are located in the spring and upset building, and for the most part are arranged in long rows. The building is composed of three bays with a full gage railroad track running down the center on which cars of raw material, mostly steel bars, are brought. This stock is removed in bundles by giant overhead cranes and placed at the furnaces for convenient handling. Finished work is hung either on overhead chain conveyors or on slat type conveyors on the floor for removal. The conveyors run parallel with the rows of furnaces on either side of spacious aisles. Miscellaneous forgings are made here such as transmission gear blanks, rear axle gears and shafts, front spindles and bolts, universal joint housings, truck hubs, steering worm sectors, torque tube flanges, rear radius rod feet, etc., etc.

Composition of the Steels for Hot Heading

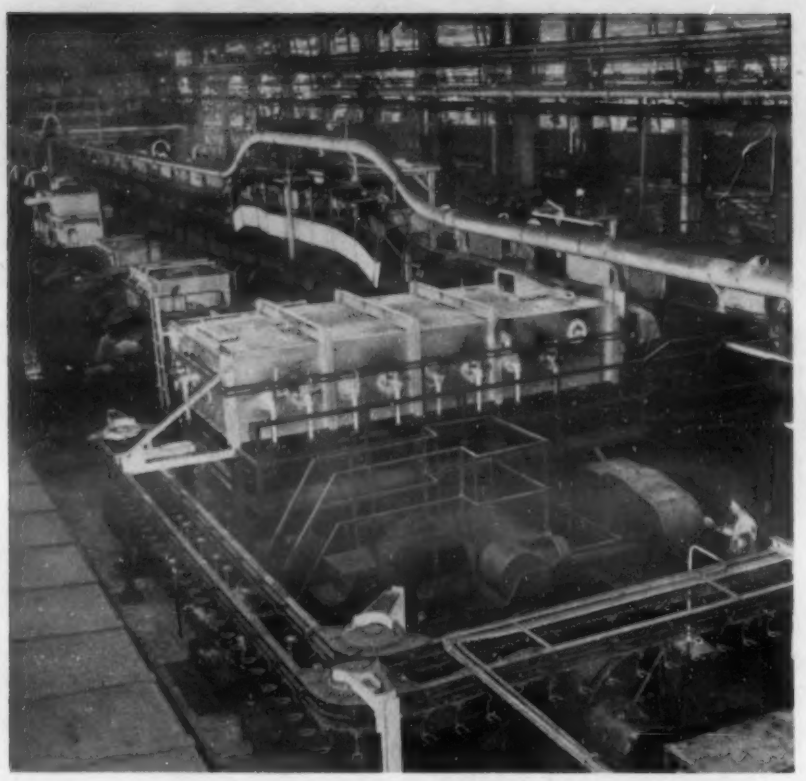
The analysis of four types of steel used in the hot heading department are given in the Table.

Table of Composition of Four Types of Steel Used for Hot Heading

	No. 1	No. 2	No. 3	No. 4
Carbon	0.35-0.40	0.30-0.35	0.15-0.20	0.40-0.45
Chrome		0.90-1.10		
Manganese	0.70-0.90	0.65-0.80	0.80-0.90	0.70-0.90
Silicon	0.07-0.15	0.10-0.20	0.10-0.20	0.07-0.15
Phosphorus	0.03 Max.	0.03 Max.	0.04 Max.	0.03 Max.
Sulphur	0.05 Max.	0.04 Max.	0.10-0.15	0.05 Max.

The plasticity of these steels at forging temperatures is good, insuring well made forgings and minimizing the wear on the upset dies. Types No. 1, 2 and 4 steels are equal in this respect, but No. 3 has an advantage as the metal flows better.

The furnaces are carefully manipulated and the scaling propensity is about the same on all of them. The temperatures of the furnaces are controlled by the operators by means of pyrometers. The bars to be heated are placed in the heating zone and removed at their discretion. An average of 3.5 cu. ft. of gas is used to heat each pound of steel at 2200 deg. F.



Rear Axle Furnace. Entire unit showing gas burners. Press in foreground.

Many of the furnaces have been rebuilt recently according to a new and improved design. Constructed of refractory shapes, insulated and encased in steel plates, these furnaces are set in 18-in. legs and are fired with gas burners. Of the slot type, each is approximately 4x4x9 ft. long, overall, while the inside dimensions are 1 ft. 9 in. wide, 6½ ft. long and 2 ft. high between the hearth and the springline of the arch. The walls consist of 9 in. of firebrick and 4½ in. of insulating brick. A flue for the waste products of combustion is built into each of the two rear corners. The area of each flue is 49 sq. in.

Dolomite (pea size), which will pass through ½ in. mesh screen, is used in hammer forging furnaces only. On hot upsetting furnaces a 2-in. bed of powdered chrome is used to prevent any possibility of the bar stock, while heating, coming in contact with the brick. Furnaces are so designed that the bars are laid on a brick ledge, the heating zone being stepped down about 1 in., thus aiding in preventing the sections of bars desired hot, from touching the furnace bottom.

Front Walls of Furnaces Removable

The front walls of these new furnaces are so constructed that they can be readily taken down and rebuilt so as to change the width of the slot to accomodate any size stock. On the lower end of this wall, which forms the upper edge of the slot, is placed a series of small pipes, joined in a coil, through which cold water flows to check the heating of the protruding stock at this point. Heat escaping through the slot is sucked up under a shield suspended in front of the furnace. A small steel trough with running cold water is bolted onto the outside of the front of the furnaces, just above the slot, as a protection to this part of the wall.

Heat is supplied by four gas burners, located in the back wall and firing straight to the front, through refractory burner blocks 10 in. in length. The center line of these burners is 17½ in. above the hearth level. As the hot products of combustion hit the front wall they are deflected down on the work and hearth and then back to the back wall where they leave by way of the flues. These burners are of the high pressure inspirator type, gas at 15 lb. inspirating air for combustion by means of venturi tubes. Air at 1 lb. pressure is applied at the rear end of the burners to increase the flexibility of the burners. Furnace temperature changes are charted by recording pyrometers. The slots of some of these furnaces are very wide and filled with brick checker work, forming three tiers of holes, through which the stock is thrust for end heating.

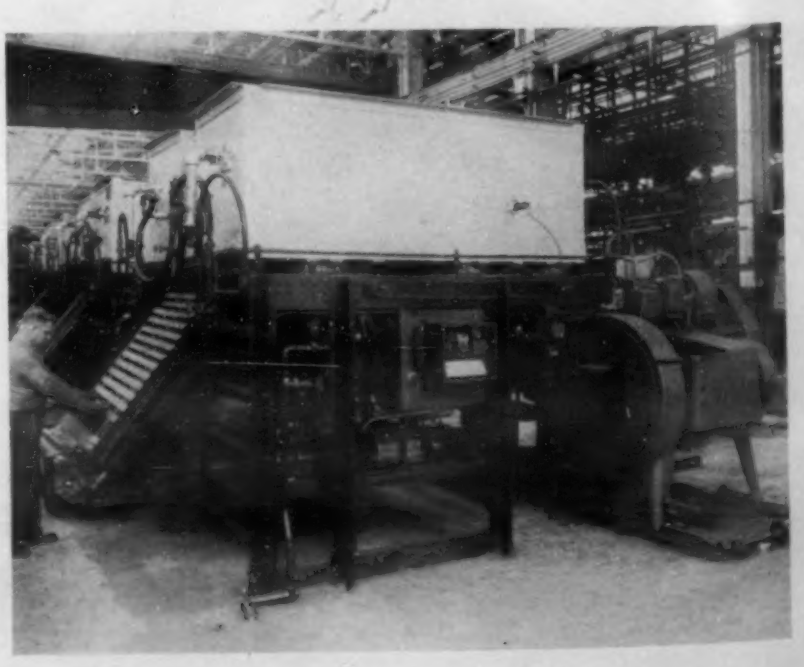
A forging or upsetting crew consists of two operators, a heater and a pressman. The heater keeps the furnace full of steel bars, which he continually hands to the pressman when hot. Gear blanks are made here, as elsewhere, in four operations in four dies in the upsetter, the operator pushing the bar progressively into first one die and then the other. When the hot portion of the bar is used up, he hands it back to the furnace man. Speed runs about 150 2½ in. blanks hourly. However, a die and setup have been devised by which 2½-in. gear blanks are made at a single stroke of the press. The forming die is made in a single piece and is closed as it must withstand greater pressure than the split die. Of course this restricts its use to parts that have no undercuts or channeled portions to prevent them from being knocked out of the die. The first part of the movement of the dies cuts a slug from the hot end of the rod, and it is held mechanically in front of the forming die until the punch forces it in. The formed blank is ejected by knockout pins. These are produced at the rate of 500 per hr. with two men.

A Novel Scaling Device

Most of these furnaces have a novel scaling device consisting of two opposed grooved and ribbed rolls about 6 or 8 in. in dia. and 4 to 6 in. wide. These are held in an upright steel frame with springs against the bearings of the upper roll forcing it against the lower. As practically all the bar stock is round, it is thrust between these rolls, when hot, and the scale is scraped off against the ribs.

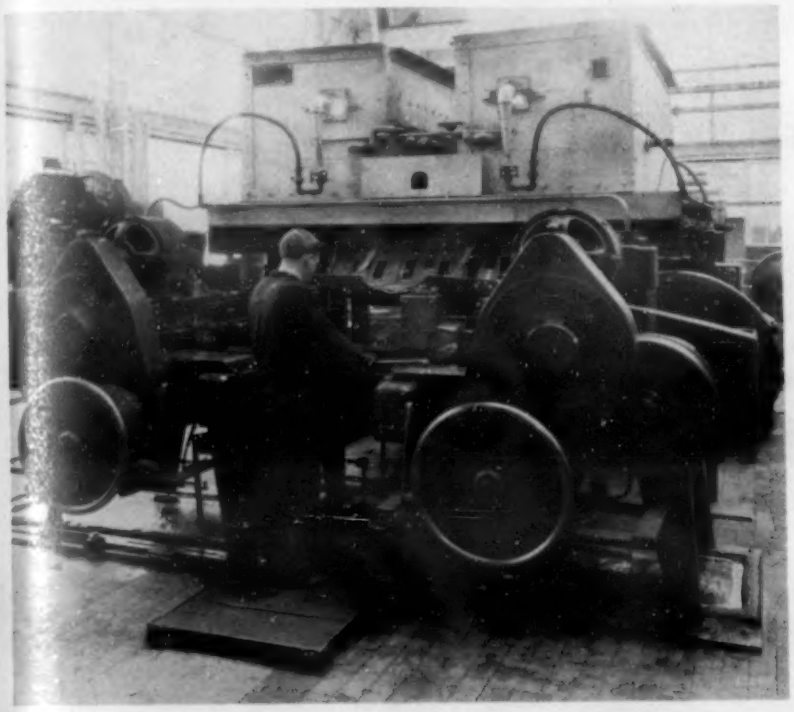
Rear axle stock, 1-5/32 in. rod 36.72 in. long, is heated in a furnace specially designed and equipped with a most unique mechanical handling system that is continuous and automatic in operation. The furnace sets on a steel platform, 7 ft. above the plant floor level, and is 3 ft. high, 8 ft. wide and 15 ft. long. This is an end heating job, one end of the stock protruding up into the furnace through a hairpin slot in the bot-

Twin Slot Type Gas Furnaces Which Heat Both Ends of Flat Spring Stock for Eye Forming. A conveyor between the furnaces carries the work along.



tom, the stock traversing the entire length of the furnace twice. The conveyor system includes a closed loop of chain, suspended between horizontal sprockets just below the furnace slot. The stock stands upright, the lower end resting in a U beam just under the chain, and it is maintained in the vertical position and moved along by clips fastened to the links of the chains.

The bar stock makes one complete turn in the furnace, finally dropping, where the U beam guide ends, into a short piece of upright pipe below. This trips a mechanism which causes the pipe and bar to revolve through an arc of 90 deg. which lays the bar on a short, double chain conveyor. In its short journey, the bar pauses momentarily under a hammer, like a riveting hammer, in the speed of its strokes, which knocks the scale from the hot end. The bar then rolls down into the feeder guides of the press or upsetter. The die has four recesses and four corresponding punches and the end of the axle is upset and formed in four operations. These are—tulip-bud shape, truncated cone, flattened into gear blank and restruck after a 90 deg. turn. The stock is carried from die to die mechanically. Released, the forging drops down a chute into a pit and on to a conveyor running at an angle of 45 deg., which carries it above the floor level. It is



Eye Forming Machines in Foreground and Twin Gas Fired Furnaces for Heating Spring Stock in Background.

then removed by an operator and placed on a chain conveyor which conveys it to another building for machining and heat treatment. Best results are obtained when a speed of 12 per min. is maintained.

Heat is supplied to the furnace through eight gas burners located along one side with two in each end. They are all on the hot side as the furnace is divided longitudinally with a refractory wall forming pre-heat and high heat chambers. These burners are similar to the ones described and air and gas are supplied at 1 and 10 lb. respectively. An automatic temperature control is provided of the potentiometer type, actuating an on-and-off motor valve in the gas and air supply lines to the burners. The furnace will hold 250 bars at a time and they are heated in 20 min. to 2250 deg. F., while temperature fluctuations are charted by a recording pyrometer.

Rod Foots Forged in a Drop Board Hammer

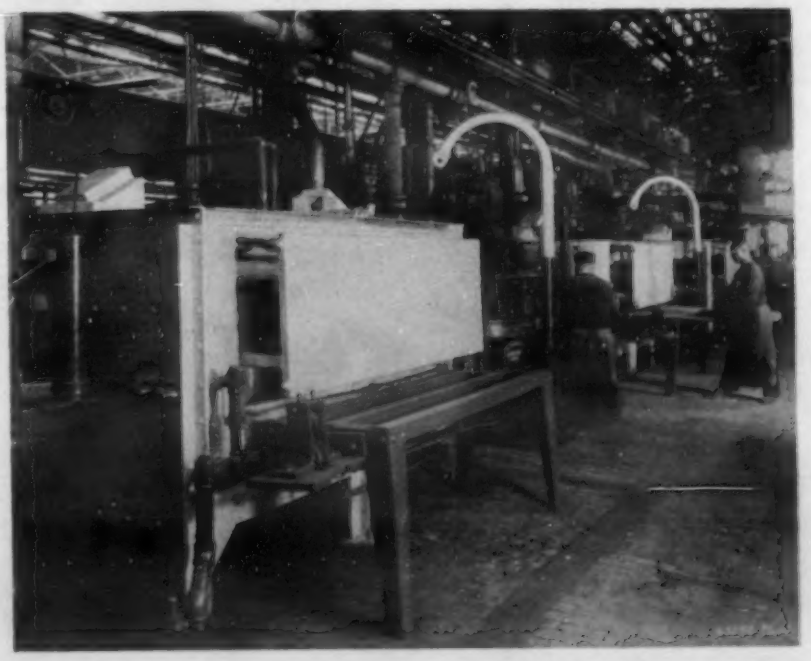
The rear radius rod foot is forged in a drop board hammer. Forging flash is removed and then it is ready

Forge Furnace Operator Pushing Hot Stock Between Rollers to Free from Scale.

for upsetting the end, preparatory to butt welding. This is done in a unit which consists of one furnace and two upsetters, one on either side. The furnace is 8 ft. long, 5 ft. wide and 4 ft. high, and sets on 4 ft. legs. Firing is accomplished with eight gas burners, four on each side and located in that half of the furnace closest to the discharge end. The stock is introduced through an opening in one end of the furnace and is pushed through, riding on water cooled pipes, by a motor operated pusher. At the other end the hot stock is pushed off the ends of the pipes and drop through an opening in the bottom of the furnace. Here is located a two-way chute with a steel plate deflector so that the hot stock can be diverted to either of the upsetters or both of them alternately. A temperature of 2250 deg. F. is maintained constantly with an automatic temperature control similar to the one described and a recording pyrometer is also part of the equipment.

The forgings are put into huge boxes and transferred by overhead crane to the trimmers. Hammer forging is done on the other side of this building and here are located long rows of power hammers. These are served with gas-fired furnaces, close to 50, of the slot type and quite similar in construction to the first described in this article.

Row of Gas Fired Forge Furnaces and Power Presses, Upsetters, etc.



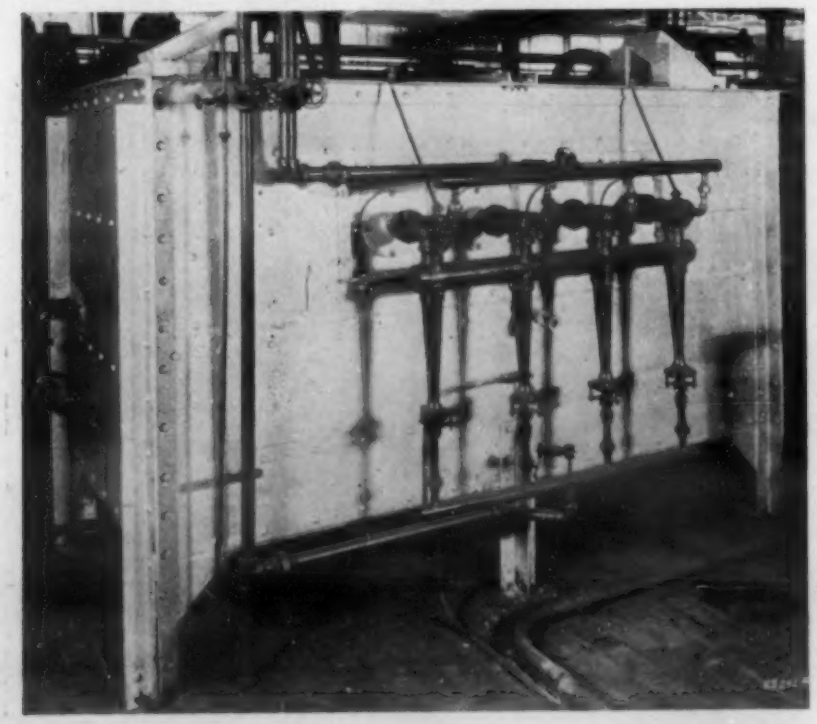
Slot Type Gas Forge Furnace (Front View). Note end of water cooling pipe coil protruding at left. Shield is also water cooled.

The firing system, however, is of a different type. Gas is fired through a burner consisting of a nozzle 6 in. long and 1¼ in. in dia., tapered to a small size at the firing end. This burns raw gas served to it through a ¾-in. pipe. A stream of secondary air for combustion (there is no primary air) is forced into the gas stream from a 2-in. open end pipe set close to the gas burner and at a slight angle to it. One of these burners is located at each end of each furnace. The furnaces are approximately 4 to 6 ft. sq. and 8 to 10 ft. long, and set on legs. Cooling is applied to the upper lip of the slot by a steel water box 4 x 8 in.

Rotary Type Furnaces Used

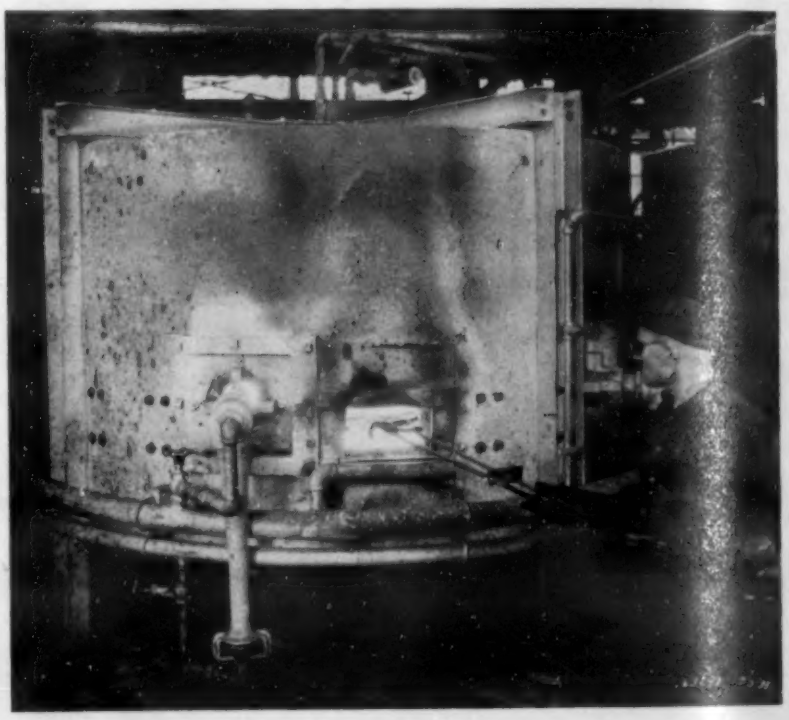
Rotary type furnaces are in evidence here, possibly two or three, and these are 8 ft. in dia. and 5 ft. high and set on 2 ft. legs. The hearth is a ring shaped steel structure, filled with fire brick and riding on wheels in a circular track below. It is supported in the center by a vertical steel shaft cooled by a series of cold water pipes, and encased by a refractory shell of firebrick where it rises in the center of the furnace. Cold water pipes are also built into the outer wall, close to the bottom of the furnace. Surrounding and bolted to the steel structure of the hearth is a ring gear meshed with a gear train and motor by which the hearth is rotated. The work is put in through an 18-in. opening, and after traveling completely around the furnace, is removed through the same opening. Firing is accomplished with two gas burners of the high pressure inspirator type, one on each side of the door and firing across the hearth and against the center pillar of refractory. Air and gas are supplied in 4 and 2-in. manifolds respectively. Automatic temperature control is provided in the form of a potentiometer actuating a motor which operates simultaneously a valve in the air line and another in the gas line.

Slot Type Forging Furnace (Back View) Showing Inspirator Type Gas Burners. Note manifold and air pipe connections for 1 lb. air at rear end of burners. This increases their flexibility. Gas is supplied at 15 lb. pressure.



Slot Type Furnaces for Flat Springs

The flat spring division is in one end of the building and stock for these is heated at both ends for eye forming. For this purpose there are 10 slot type furnaces, operated in pairs, and set on opposite sides of an aisle along which runs a belt conveyor bringing in the raw material, steel strips or flats, cut to length. Each furnace is 3½ ft. wide, 3 ft. high, and 6 ft. long and



Circular Gas Fired Forge Furnace with Rotating Hearth. Note hearth moving mechanism below.

sets on a steel structure 6 ft. above the floor. They are similar structurally to those first described in this article. As stated they are set in pairs with the slots facing and just far enough apart so that the ends of the flats, passing between, protrude through the slots and into the furnaces the required distance. Between each pair of furnaces is a double chain conveyor, motor driven, each chain forming a closed loop.

The chain loops form a triangle, one leg running parallel to the furnace slots, the other at right angles, descending to the floor and the hypotenuse running from this point up to the further ends of the slots. Small steel angles are bolted to the links of these chains and the flats are loaded onto these by operators on the floor. The chains carry them vertically to the slot level and then horizontally through the slots to the further end where they are automatically dumped off into holders. Here they are removed by an operator who places them in twin eye-forming machines which form the eyes simultaneously on both ends of the flat. Heat is supplied through a high pressure inspirator type gas burner in each end of each furnace.

The Embrittlement of Boiler Steel*—V

A Correlated Abstract

By EVERETT P. PARTRIDGE AND W. C. SCHROEDER

Laboratory Investigations of the Failure of Steel Under Combined Stress and Chemical Attack (concluded)

IN THE PRECEDING SECTION attention was concentrated on tests in which steel was exposed to chemical attack while subjected to presumably steady stresses, although in many cases the actual magnitude of the applied stress or of local stress concentration was not known. Steel in a boiler must, however, withstand not only steady stress, but also repetitions of stress resulting from variations in operating pressure and rates of steaming, as well as those due to periodical outage for cleaning. An examination of the information on the combined effects of cyclic stress and chemical attack is therefore desirable.

Repeated Stress at Room Temperature

IT HAS long been known that steel will fail when subjected to a repeated stress well below the limit which it would carry indefinitely if the stress were steady. This problem of fatigue has received much attention and the endurance limit, that is, the stress which a material will withstand without failure through a very large number of cycles, has been determined for various steels in the absence of any chemical attack. Since 1926 the important effect of corrosion upon fatigue failure has been studied in detail by McAdam. During his extensive work he has investigated the behavior of a wide variety of ferrous and and non-ferrous materials. In his more recent papers[147, 148, 149], he has discussed the significance of his results with respect to the cracking of steel in boilers. References to his earlier publications may also be found in any of these three papers.

McAdam developed his studies of corrosion fatigue as a result of applying a stream of cooling water to the surface of rotating steel test pieces to obviate thermal effects in an ordinary fatigue test[150]. He found that the stress-cycle curve under these conditions dropped below that for the steel in air, in other words, the steel would fail under stresses below the endurance limit. Examination of the test pieces revealed minute dull spots which, under the microscope, were found to be small patches of oxide covering pits. Short transverse cracks had formed at these pits as a result of the local concentration of stress.

The process of failure under combined cyclic stress and chemical attack, as visualized by McAdam, may be stated in generalized form as follows:

1. Cyclic stress accelerates chemical attack of the water upon the metal, producing pits which are sharper and deeper than those resulting from corrosion in the absence of stress.
2. The stress upon the sound metal at the base of a pit is continuously increased as the pit develops, and this increasing stress correspondingly increases the rate of attack.
3. Ultimately, the stress concentration is so increased by the corrosion process that cracking by ordinary fatigue is induced and continues to failure.

A photomicrograph of a long crack in a boiler due to corrosion fatigue, described by McAdam[149], is shown in Fig. 15.

McAdam believes that intercrystalline failure of boiler steel at seams and rivet holes is a special case of the general process just outlined, and that it may occur in the absence of caustic soda under the following conditions: High stress, low cycle frequency, slight corrosion, and very little accumulation of corrosion products.[148, 149] He strongly discounts the theory

* Published by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.) This summary has been prepared in connection with an investigation conducted under a cooperative agreement between the Joint Research Committee on Boiler Feed Water Studies and the United States Bureau of Mines. The general investigation is supervised by a subcommittee of which J. H. Walker is chairman, and is carried out at the Nonmetallic Minerals Experiment Station of the Bureau of Mines, maintained in cooperation with Rutgers University at New Brunswick, N. J. The interpretations and comments in this summary are those of the authors, and the summary as a whole is to be regarded as a report to the subcommittee rather than by the subcommittee.

Previous installments of this correlated abstract appeared in the June, July, September, and October, 1935, issues of METALS & ALLOYS.

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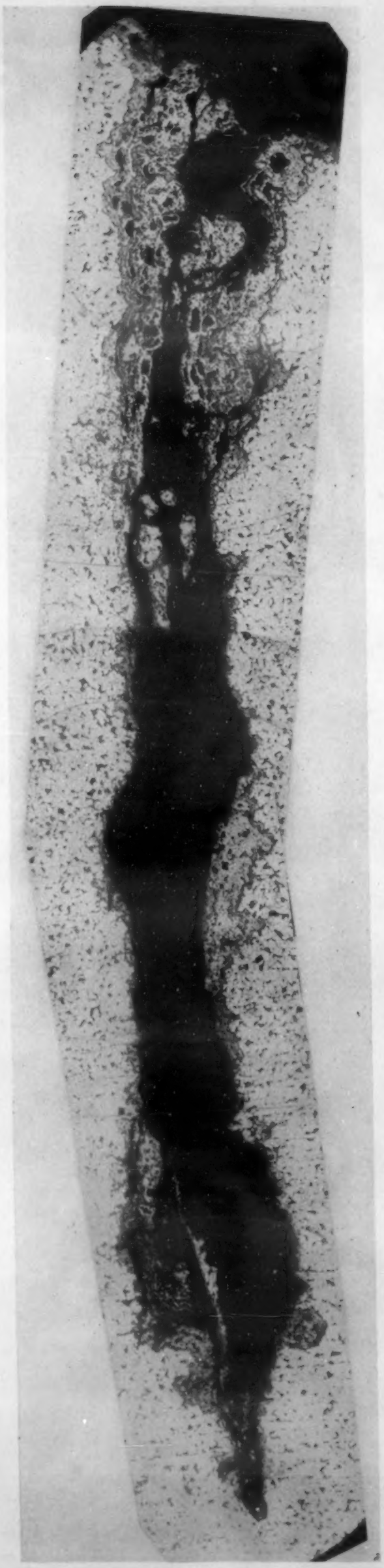

Fig. 15. Corrosion-Fatigue Crack between Holes in Tube Sheet of Boiler. (Photomicrograph by D. J. McAdam, Jr.)

that boilers may fail due to embrittlement of the steel by hydrogen.[149]

In addition to tests in which specimens were run to failure while continuously in contact with water, McAdam employed prior-corrosion tests in which specimens were subjected to corrosion while under cyclic stress for a limited time insufficient to cause failure and were then dried, oiled, and tested to failure in air. The endurance in this second-stage fatigue test in air served as a measure of the damage to the metal during the stress-corrosion in the first stage. The results of both types of tests have been correlated and expressed in a complex series of graphs derived from the original stress-cycle data.

McAdam's work is qualitatively of the greatest significance with respect to the failure of boilers. However, since his experiments were all carried out at room temperature, with waters differing rather widely in composition from most boiler waters, and with free access of air, the results cannot be applied quantitatively in the analysis of what happens to stressed boiler steel at an elevated temperature in contact with water which is generally quite alkaline and nearly free from dissolved oxygen.

In addition to the stress concentration produced by the chemically formed notches, it is possible that hydrogen embrittlement may have contributed to the accelerated failure of McAdam's specimens, as suggested by Speller.[151] The same chemical process which produced the corrosion pits must also have liberated hydrogen at the surface of the steel. However, the amount of this hydrogen absorbed by the steel may have been limited more or less by reaction with the oxygen of the air, which was in free contact with the water prior to and during the tests.

At about the same time that McAdam was commencing his studies of corrosion fatigue by water at atmospheric temperature, Lehmann [152] investigated the effect of water and a few concentrated salt solutions at 205 deg. F. (96 deg. C.) on samples of 0.13 and 0.33 per cent carbon steel under cyclic stress in a rotating-cantilever apparatus. In general, the stress-cycle curves were displaced downward toward lower endurance limits by the action of hot water or aqueous solutions, as compared with the curve obtained in air at 63 deg. F. (17 deg. C.). Although corrosion was minimized by protecting the test pieces from the air, some pitting was observed. How much of the observed effect in each case was due to corrosion fatigue, to some other possible action of the solution, as hydrogen embrittlement, or to the difference in temperature cannot be estimated. The greatest decrease in endurance limit for the 0.13 carbon steel was about 3,000 lb. per sq. in., resulting from contact with a 33 per cent solution of sodium nitrate. The fractures in this case were noted to occur at an angle of less than 90 deg. with the axis of the test piece, and slight pitting was observed with some concentration of the pits in the region where fracture occurred.

Some evidence concerning the effect of chemical attack upon fatigue failure at very low cycle frequencies has been obtained at the National Physical Laboratory in Great Britain by repeated bending tests on steel in contact respectively with air, water, brine, and a concentrated solution of sodium hydroxide at room temperature and at 100 deg C. Test pieces 8 by 0.75 by 0.5 in. supported on cylinders 5.9 in. (15 cm.) apart were bent repeatedly through an angle of 15 deg. in an Amsler testing machine, the load required for deflection being measured. Rosenhain and Murphy,[153]

In the first of two papers describing this work, reported that with a period of 5 min. between successive deflections, the medium in contact with the steel exerted no measurable effect, but that when the test piece was allowed to remain in the medium for 24 hrs. between bends, both tap water and brine caused a notable decrease in the endurance as measured by the number of bends to failure. Visible corrosion occurred in both of these cases. In the solution containing 500 grams of sodium hydroxide per liter the steel remained bright, and the endurance was nearly the same as in air. Examination of specimens before failure showed many cracks in the test pieces immersed in brine and in tap water at a time when no cracks were evident in the specimens in contact with air or with sodium hydroxide solution.

From further tests in which varying exposures to air and tap-water were used between the bends at intervals of 24 hrs., Rosenheim and Murphy concluded that approximately half of the decrease in endurance was to be attributed to contact of the steel with water during the actual bending, and half to contact during the resting period. They noted that the appearance of the cracks in specimens immersed in water suggested an apparent reduction in ductility during the resting period.

Jenkins and West[154] extended this investigation, confirming the fact that contact with water during the actual process of bending was responsible for a definite decrease in endurance. They also conducted similar tests on specimens bent every 24 hrs. at room temperature after being maintained at 100 deg. C. in contact with air, tap-water, or sodium hydroxide solution in the intervening periods. There was little difference in the number of bends to produce failure in the three cases, but it is perhaps significant that a greater force was required to bend the pieces which had been in contact with the two solutions than those which had been held in air.

When the specimens were bent every hour instead of every 24 hrs., those immersed in sodium hydroxide solution at 100 deg. C. between bends showed a much lower endurance than those held in air at the same temperature. The effect of the solution was apparently obscured in the tests at 24-hr. intervals by aging of the steel, which was shown by independent tests in air to decrease the endurance markedly.

The fact that a concentrated solution of sodium hydroxide did not decrease the endurance in the repeated bending tests at room temperature is quite in line with the results of some repeated-torsion tests made by Lea[155] on round specimens of 0.14% carbon steel in contact respectively with air, 10 per cent sulphuric acid and 10 per cent caustic soda at room temperature.

As a result of active corrosion probably accompanied by hydrogen embrittlement, the stress-cycle curve for the specimens exposed to acid dropped very rapidly, that is, decrease in stress produced only a slight increase in the number of cycles to failure, in contrast to the usual flattening out of the curve to indicate an indefinitely long life when the stress is below a certain limit. The stress-cycle curve for the specimens exposed to the caustic soda lay, however, above the curve for the specimens tested in air, indicating that contact with the highly alkaline solution actually enabled the steel to endure more severe stress than it would stand in an ordinary test. In spite of the higher endurance limit, however, the final fractures of the specimens tested in sodium hydroxide were typical of a brittle material.

Effect of Corrosion Inhibitors

Protection of metal against corrosion is generally believed to depend on the maintenance of a surface film which is frequently so thin as to be invisible to the eye, although its presence can be proved by other means. When the metal is subjected to repeated stresses, the stability or the rate of repair of this protective film may be the controlling factor in determining whether or not failure will ultimately occur, as pointed out by Speller, McCorkle and Mumma.[156] These investigators found that a concentration of 200 parts per million of sodium dichromate effectively inhibited stress corrosion of steel immersed in a synthetic water containing 25 parts per million each of sodium sulphate[157] while subjected to cyclic stress in a rotating-beam test. Corrosion by brines of considerably higher sodium chloride content could also be inhibited by higher concentrations of dichromate or chromate, the latter showing somewhat superior results.[156]

Repeated Stress at Boiler Temperatures

WITHOUT in any way minimizing the value of the investigations just summarized, the present writers feel that observations made at room temperature, or even at 212 deg. F. (100 deg. C.) should not be used to interpret the processes taking place in boilers at considerably higher temperatures. Increase in temperature not only greatly increases the rate of reaction between water and steel, but also greatly decreases the solubility of oxygen in water. Under boiler conditions, the oxygen concentration is generally so low that the black magnetic oxide of iron is formed. Upon the relatively unknown properties of this oxide coating at the operating temperatures the whole process of stress corrosion in boilers may depend. Moreover, as pointed out in a preceding part of this survey, the mechanical properties of steel at boiler temperatures differ considerably from those at room temperature. Laboratory investigations at these elevated temperatures would seem to offer the most certain insight into the effect of repeated stress in promoting chemical attack upon steel in boilers.

An admirable study of the endurance of steel under repeated stress in tension while in contact with air, water, and different concentrations of sodium hydroxide and of sodium phosphate at 525 deg. F. (275 deg. C.) has been carried out by Holzhauer,[158] who used three different steels with carbon contents ranging from 0.10 to 0.15 per cent. Most of his tests were carried out with specimens from an 0.75-in. (20-mm.) plate which had been held at 1690 deg. F. (920 deg. C.) for 1 hr. after rolling. This steel showed an average carbon content of 0.125 per cent, with a slightly higher value of 0.152 per cent in the center.

Holzhauer's apparatus was designed to subject a notched cylindrical specimen to a tensile stress alternating between a minimum and a maximum value at the rate of 280 cycles per min. As indicated in Fig. 16, the loading was accomplished by a crank mechanism pulling on a spring attached to one end of a simple lever, the other end of which exerted a pull upon the test specimen. With the crank mechanism in its lowest position, the test specimen was subjected to the minimum stress which in most of the tests was 7,400 lb. per sq. in. As the crank moved through 180 deg. the stress was increased to the maximum. The rod transmitting the stress to the test piece entered the bomb through

a water-cooled gland with leather packing which is claimed to have maintained a tight seal with only a slight and measurable amount of friction.

The test pieces used throughout most of the work were 90 mm. long with 15-mm threaded ends. The diameter was 10 mm. and at the center a 30-deg. notch with a radius of 0.05 mm. at the base was cut out to give a diameter of 6 mm. This sharp notch was found to be quite reproducible. Any test pieces which showed decided tool marks or other irregularities during a preliminary microscopic examination were rejected.

Solution Composition

The results of the tests are summarized by the stress-cycle curves of Fig. 17. The endurance limit of 29,600 lb. per sq. in. in air at 525 deg. F. (275 deg. C.) was the same as the limit at room temperature. At the elevated test temperature, contact with ordinary tap water lowered the endurance limit slightly to 28,800; a low concentration of 0.07 grams of sodium hydroxide per liter increased it to 31,900; a higher concentration of 50 grams of sodium hydroxide per liter dropped it again to 29,000, almost the same value as for tap water; and the still higher concentration of 280 grams of sodium hydroxide per liter caused a reduction to 25,600 lb. per sq. in. This variation in the endurance limit is thoroughly in agreement with the relative rates of reaction of iron with various concentrations of sodium hydroxide, as shown by the curve of Berl and his co-workers in Fig. 1 of this report. [M. & A., June, 1935]. The low concentration of 0.7 grams of sodium

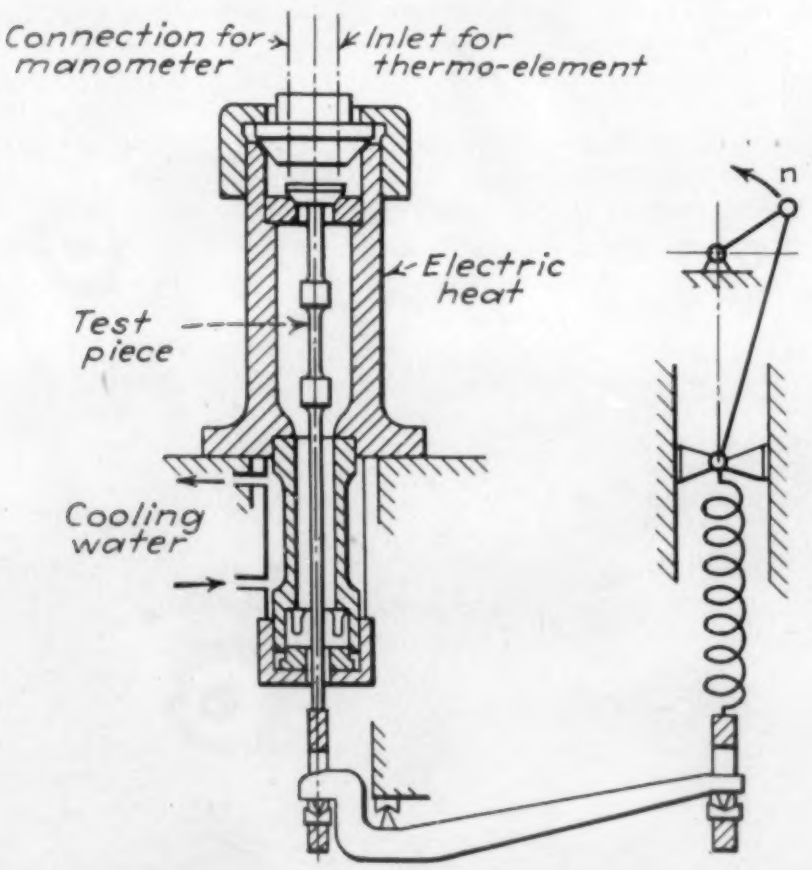

Fig. 16. Apparatus Used by Holzhauer for Testing Effect of Cyclic Tensile Stress and Chemical Attack upon Steel at Elevated Temperature. (From Mitteilungen der Materialprüfungsamt an der Technischen Hochschule Darmstadt, Heft 3.)

hydroxide per liter evidently assisted in maintaining a protective oxide coating on the steel and retarded the process of stress corrosion. As the concentration was increased the oxide coating became less and less protective, and the accelerating effect of stress upon corrosion and of corrosion pitting upon fatigue failure became increasingly important.

One of the most significant features of Fig. 17 is the very sharp elbow in the curve for 280 grams of sodium hydroxide per liter. The form of this curve indicates that when the repeated stress was below 25,600 lb. per sq. in., the test specimens remained unbroken for a

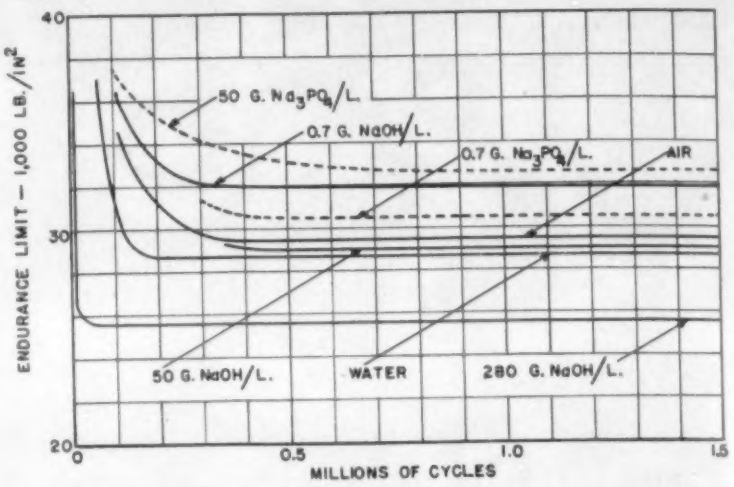

Fig. 17. Variation of Endurance Limit of Low-Carbon Steel in Contact with Various Solutions at 275 deg. C. (Holzhauer).

very large number of cycles, but when the stress was increased only a slight amount above this endurance limit, the test specimens broke after a very small number of cycles. In this case the endurance limit is also apparently a critical value separating a region of no failure from one of almost immediate failure. It may be noted here that the local stress at the base of the sharp notch must have been very considerably higher than the average stress given above, which was presumably calculated on the diameter at the base of the notch.

The broken curves in Fig. 17 represent tests with solutions of sodium phosphate at the same test temperature of 525 deg. F. (275 deg C.). Here there is a progressive increase in the endurance limit with increase in concentration. While 0.7 gram of tri-sodium phosphate per liter increased the limit only to 30,400 lb. per sq. in., somewhat below the value for the corresponding concentration of sodium hydroxide, the use of 50 grams of tri-sodium phosphate per liter resulted in the highest value obtained, 32,700 lb. per sq. in. Holzhauer observed that in these tests the steel was covered with a dense smooth coating of iron phosphate. Judging by the experimental results, this coating effectually prevented stress corrosion, so that the failure was essentially by fatigue alone.

Holzhauer also found that, with a repeated maximum stress of 32,700 lb. per sq. in., an increase in concentration of sodium hydroxide over the range from 280 to 510 grams per liter resulted in a nearly constant value of from 6000 to 7000 cycles before failure. At this temperature of 525 deg. F. (275 deg. C.), the rate of corrosion under stress apparently is high over a considerable concentration range, although the life was approximately doubled when the concentration was lowered to 190 grams per liter. Decreasing the temperature to 465 deg. F. (240 deg. C.), increased the number of cycles before failure approximately fivefold, showing that the rate of attack is noticeably decreased as the temperature is lowered.

Cold working the steel by stretching it 10 per cent did not have any deleterious effect upon its life. Indeed, the cold-worked steel showed a higher endurance limit in a concentration of 280 grams of sodium hydroxide per liter than did the original material.

Type of Crack

Microscopic examination of the failed test specimens led Holzhauer to the interesting conclusion that the tendency toward intercrystalline cracking was greatest in the specimens broken in contact with the lowest concentration of sodium hydroxide, 0.7 grams per liter. In all cases the cracks appeared to be predominantly trans-crystalline, but with this lowest concentration of sodium hydroxide, and also to a lesser extent with the concentration of 50 grams per liter, a number of branch cracks which tended to follow grain boundaries were evident. Specimens from the highest concentration of sodium hydroxide, 280 grams per liter, showed strong corrosion at the base of the notch and little evidence of intercrystalline cracking.

From the evidence afforded by microscopic examination of these specimens Holzhauer has come to the same conclusion as McAdam, that intercrystalline cracking will be favored by a condition which produces little general corrosion. The possibility that intercrystalline failure may result from the action of an ordinary boiler water over a long period of time on steel under high stress, particularly repeated stress, accordingly should not be ignored.

Conclusions

The information concerning the combined effects of cyclic stress and contact with aqueous solutions upon the behavior of low-carbon steel may be summed up as follows:

1. Corrosion-fatigue of steel at room temperature due to water in free contact with air may cause failure under nominal stresses well below the endurance limit.
2. Water and concentrated salt solutions at 100 deg. C. in the absence of air likewise induce corrosion-fatigue to a limited extent.
3. At boiler temperatures low concentrations of sodium hydroxide apparently retard failure of steel subjected to cyclic stress, while high concentrations accelerate it.
4. When steel is subjected to repeated stress in contact with sodium hydroxide solutions at boiler temperatures both hydrogen embrittlement and corrosion fatigue may play important parts in producing failure.
5. Repeated stress, by its mechanical effect in rupturing or rendering more permeable the protective oxide coating upon steel in contact with water or aqueous solutions may accelerate failure by increasing the rate of chemical reaction.
6. It may be possible to prevent cracking of boiler metal, whether due to hydrogen embrittlement or corrosion fatigue, by the maintenance of protective coatings produced on the steel by the addition of specific chemicals to the boiler water.
7. In laboratory studies of corrosion fatigue of boiler steel only a slight tendency toward intercrystalline cracking has been observed.

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Final Summary (Concluded with this discussion)

THE preceding survey [concluded with this discussion], has attempted to interpret the published information which may bear upon the question of embrittlement failures in boiler steel. Insofar as data were available, emphasis has been placed upon what happens at boiler temperatures as contrasted to the possibly quite different behavior at room temperature.

From a consideration of the chemical reaction between water and iron, it has been established that hydrogen and the black magnetic oxide of iron (Fe_3O_4) are the reaction products when oxygen is absent or present only in very low concentrations. The oxide coating formed by the initial contact of the iron and the water acts as a mechanical barrier tending to prevent further reaction, but this protective action is greatly affected by various substances present in solution.

It is known that when hydrogen is produced by chemical reaction at a steel surface, it tends to diffuse into the metal, with the result that the steel behaves in a brittle manner, although its tensile strength is not affected. Only a low concentration of hydrogen in the steel is necessary to produce a very considerable decrease in ductility. Since hydrogen is a product of the reaction between iron and water, the apparently brittle failure of steel in boiler seams may be due to the action of stress upon metal rendered brittle by hydrogen.

In addition to any embrittlement produced by chemical action, steel itself is more brittle at boiler temperatures than at room temperature. The properties of steel at boiler temperatures should be used as a basis of reference for any study of embrittlement failures.

When steel is subjected to chemical attack while under stress, failure commences at a point where the local stress is greater than the average. The local stress necessary to initiate failure is probably very high.

On the basis of the material reported in this survey, the following suggestions are presented concerning the mechanism of embrittlement failure, and the possible means of preventing such failure by control of the boiler-water composition.

Mechanism of Embrittlement Failure

A fundamental distinction must be made between two possible ways in which mechanical stress may produce failure in conjunction with chemical attack. On one hand, it is possible that mechanical stress accelerates a highly localized corrosion. On the other hand, it is equally possible that mechanical stress simply causes the ultimate cracking of steel previously made brittle by the absorption of hydrogen. In the first case, stress is essential in producing dangerous chemical attack; in the second, the chemical attack leading to a brittle condition is relatively independent of stress except as the latter tends to offset the protective effect of the oxide coating on the steel.

No very definite evidence has been found in support

of the theory of intergranular corrosion, although the possibility of selective attack of this type as a special case of corrosion fatigue must be kept in mind. The experimental results used in support of the theory of intergranular corrosion may generally be used also in support of the theory of hydrogen embrittlement.

A thoroughly logical picture of the way in which the failure of boiler steel may be caused by hydrogen embrittlement may be built up on the basis of the information discussed in this report. When a boiler goes into operation, its internal surfaces are immediately covered with a layer of magnetic oxide. This layer under ordinary conditions forms an almost impassable barrier between the boiler water and the steel. This barrier may be broken through, however, by either chemical or mechanical means. Increasing the concentration of sodium hydroxide tends to destroy the oxide coating. In either case, continued chemical reaction results. This chemical reaction produces hydrogen which diffuses into the steel and causes a definitely brittle condition, probably by setting up internal stresses at grain boundaries and cleavage planes.

Although the steel may be rendered very brittle by the absorption of hydrogen, no serious permanent damage is done until a localized stress at some point reaches a very high value, probably well up toward the ultimate strength of the metal. A piece of normally ductile steel subjected to a high local stress of this sort would yield slightly, automatically reducing the local stress by distributing it over a larger section of metal. The embrittled steel, however, instead of gliding along slip planes in the manner of ductile metal, will ultimately crack at the point of high local stress. Although the initial failure may be only the boundary between two grains in the outermost surface layer, it represents a permanent damage to the steel. The high local stress, instead of being reduced in intensity, may then be transmitted to the next layer, with the result that the failure is eventually repeated here. As long as the concentration of hydrogen in the steel is sufficient to maintain it in a brittle condition, and as long as the local stress in the outermost sound layer of metal is sufficient to cause failure, the process of cracking will continue.

In applying this concept to actual conditions in a boiler, it should be remembered that the stresses in riveted seams are not simple tension stresses. Instead they are much more likely to include bending stresses in which a certain portion of the surface metal is subjected to a stress greatly above the average stress on the whole cross-section. If, in addition, the stresses are not static, but are repeated, the initial development of a crack in the surface of the steel immediately tends to accelerate chemical attack at its base until eventually the stress in this region is high enough to result in fatigue cracking.

When water alone is in contact with steel, the oxide coating so greatly retards the rate of reaction that the hydrogen liberated is insufficient to produce any marked embrittlement at room temperature. It is, however, barely possible that at elevated temperatures in a boiler the rate at which hydrogen is evolved by an ordinary boiler water would be sufficient to produce a noticeable increase in brittleness of the boiler steel. Here the mechanical effect of repeated stress in damaging a protective coating of oxide might be a most important factor in promoting the chemical attack.

The theory that hydrogen embrittlement may be responsible for the failure of riveted seams and expanded tube ends, like all logical theories, may be proved incorrect by subsequent experimentation. Careful investigation of its validity by tests under boiler conditions is a matter of the greatest importance if a rational basis for the prevention of embrittlement failures is desired.

Prevention of Embrittlement Failure

As has been noted, the oxide coating inevitably formed on the steel surfaces of a boiler in contact with water normally protects the metal from further reaction to produce hydrogen, except at a very slow rate. If, however, conditions are such as to allow the concentration of an alkaline boiler water in riveted seams, the protective effect of the oxide coating in these seams will ultimately be affected, with resultant acceleration of the rate at which hydrogen is liberated at the steel surfaces. An increase in sodium chloride concentration will presumably have a similar effect. Sodium sulphate in solution, even in small quantities will at first tend to maintain the protective layer against the action of sodium hydroxide, but as the concentration of the latter builds up, particularly if sodium chloride is also present in appreciable amounts, the beneficial effect of the sulphate will disappear. The rate of attack of the saline solution on the metal in the riveted seam will therefore increase as the solution concentrates. The process of concentration will furthermore tend to be accelerated by the decomposition of water to liberate hydrogen. Unless some additional factor enters the situation, the rate of reaction between water and steel will therefore tend to increase indefinitely. If, however, some other protective layer, stable in contact with the saline solution, can be deposited upon the steel, the self-accelerating reaction between the steel and the solution may be retarded or even stopped. The new protective layer might be produced on the steel by the chemical action of some hypothetical substance added to the boiler water, or it might result simply from the precipitation of a continuous, impervious deposit of some dissolved substance such as sodium sulphate or the less soluble constituents commonly found in boiler scales. It is perhaps pertinent to point out that embrittlement has generally occurred in boilers operating with boiler waters distinguished for their freedom from scale formation.

In any case, the prevention of embrittlement failures, insofar as it may be accomplished by control of water conditions, must depend fundamentally upon maintaining a stable, self-repairing coating upon the steel which effectively separates it from contact with the water. An investigation of the behavior of the various coatings which might be produced by the addition of specific substances to the boiler water is probably the most important step which can be taken in the attempt to prevent embrittlement failures from the standpoint of boiler-water control.

Acknowledgments

To the many individuals who have contributed information or supplied material the writers wish to express their appreciation. Acknowledgment is due particularly to the following: E. Berl, formerly of the Technische Hochschule, Darmstadt, Germany, now of the Carnegie Institute of Technology; H. J. Gough of the National Physical Laboratory, Great Britain; Director Lupberger of the Vereinigung der Grosskesselbesitzer, Berlin, Germany; D. J. McAdam of the U. S. Bureau of Standards; A. E. White and R. Schneidewind of the University of Michigan, and the members of the subcommittee of the Joint Research Committee for Boiler Feed Water Studies supervising this project.

THE PAINTING OF METALS

An Extended Abstract

A SERIES of papers before the Paint and Varnish Division of the American Chemical Society at the April, 1935, meeting, dealt with the painting of metals. The papers were the following:

"The Modern Theory of Corrosion." W. W. Kittelberger, N. J. Zinc Co.

"The Preparation of Iron and Steel for Painting." V. M. Darsey, Parker Rust-Proof Co.

"The Painting of Zinc and Zinc Alloy Surfaces." H. A. Nelson, N. J. Zinc Co.

"The Painting of Aluminum and its Alloys." J. D. Edwards and R. I. Wray, Aluminum Co. of America.

"The Painting of Magnesium Alloys." A. W. Winston, J. B. Reid and W. H. Gross, Dow Chemical Co.

Modern Theory of Corrosion

Kittleberger classifies corrosion as occurring (a) by direct chemical attack, (b) with displacement of another metal from solution in accordance with the electrochemical series, (c) with displacement of hydrogen being removed by some further chemical reaction.

The last type, invisible separation of hydrogen from aqueous solution, is responsible for many troublesome corrosion problems, including corrosion beneath paint films. In this, oxygen must be present to combine with hydrogen at cathodic areas, or corrosion would not proceed. The corrosion process involves solution of metal ions at anodic areas, and separation of an equivalent amount of hydrogen at cathodic areas. As the hydrogen ions combine with oxygen, hydroxyl ions are left in excess and the electrolyte next to the cathodic areas becomes alkaline. By diffusion this alkali combines with the metal ions next the anodic areas and the metal hydroxide is formed. Depending on conditions, the metal hydroxide may precipitate either in the body of the liquid or on the metal. It may exert some protective action if it forms on the metal.

Since both anodic and cathodic reactions are involved, corrosion can be stopped by stopping or preventing either set of reactions. Anodic reactions are prevented by keeping moisture away from the metal, by any impervious barrier, which may be a film of another metal, a paint film, or an adherent film of corrosion products. If the solubility of the corrosion product is reduced by something present in the electrolyte, the corrosion products tend to deposit on the metal so that the film is self-repairing, thus acting as an effective barrier and stopping anodic attack. Soluble chromates in the electrolyte tend to produce insoluble metal chromates as fast as metal ions are formed at anodic points, so chromates tend to produce self-repairing films. If the film of corrosion products lets the corroding anions (SO_3', Cl', etc.) through to the metal but keeps oxygen away, the area under that film has to be anodic. Spotty deposition of corrosion products of this type leads to pitting.

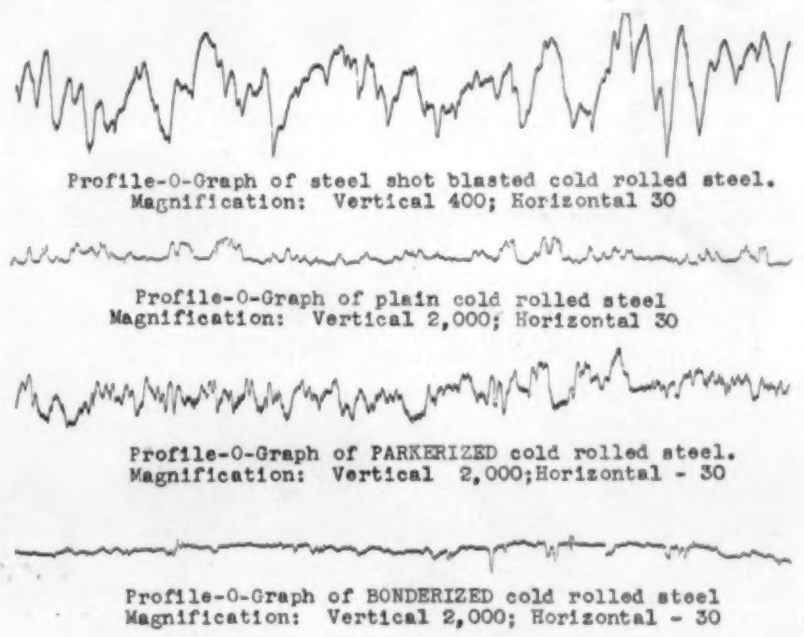
No paint film is absolutely impervious to moisture, or oxygen. Thus paint is not an absolute barrier to the agents that cause the cathodic reactions.

The vast majority of the paints that actually inhibit corrosion do it by anodic control, the priming coat must itself contain correct chemical constituents to itself produce an insoluble, impervious layer right on the metal, or to produce it by reaction with the corrosion product.

Whether one relies merely on paint as a mechanical barrier or whether it is also used as a carrier for an inhibitive chemical, the paint won't do its job if it flakes or peels off, so a basic requirement is that the paint must stick. A roughened surface on which the paint can get a toe-hold is in a better condition for adhesion than a smoothly polished one. Grease films on the metal will prevent adhesion unless the grease is fully soaked up into the paint vehicle.

Preparation of Iron and Steel for Painting

Darsey points out that cold rolled steel has greasy material jammed down into the surface which is very


Profile-O-Graph of steel shot blasted cold rolled steel.
Magnification: Vertical 400; Horizontal 30
Profile-O-Graph of plain cold rolled steel
Magnification: Vertical 2,000; Horizontal 30
Profile-O-Graph of PARKERIZED cold rolled steel.
Magnification: Vertical 2,000;Horizontal - 30
Profile-O-Graph of BONDERIZED cold rolled steel
Magnification: Vertical 2,000; Horizontal - 30

A Profilograph Chart Revealing the Type of Surface Produced on Metal by the Various Methods Outlined in the Darsey Paper.

hard to remove. Alkali and solvent degreasing methods do not alter the metal surface itself. But if the final rinse of an alkali process carries 0.01 per cent alkali, enough is left on the surface to make the paint applied over it fail prematurely.

Vapor degreasing has limitations when the work is of such shape that the solvent is trapped. A solvent wipe may be required to give real cleanliness to a metal previously alkali or vapor cleaned. A really clean surface, once obtained, must be painted at once, lest it start to corrode.

Mechanical cleaning such as sandblasting or shot blasting preferably after degreasing, not only cleans the surface but roughens it to give the paint a toe-hold. Pickling has a similar etching effect, and takes off scale as well, but requires very thorough water wash to remove salts, and immediate drying. Such material, again, must be promptly painted.

In order to produce a protective, adherent, nonmetallic film with some corrosion inhibiting power, Darsey advocates treatment with a solution ("Bonderizing," actual composition not given) containing free phosphoric acid, metallic acid phosphates and an oxidizing agent. Ferrous phosphate is slightly soluble in phosphoric acid solutions. The treatment attacks the

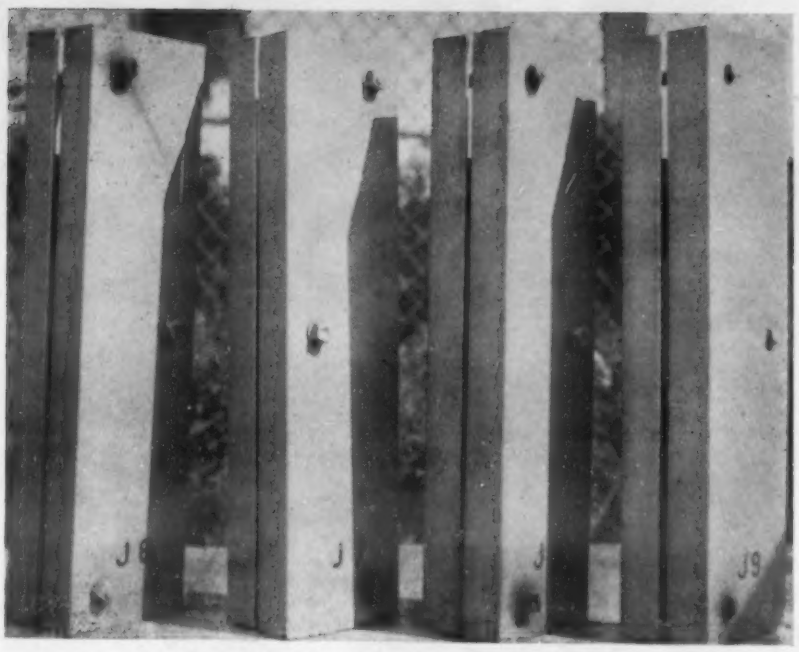
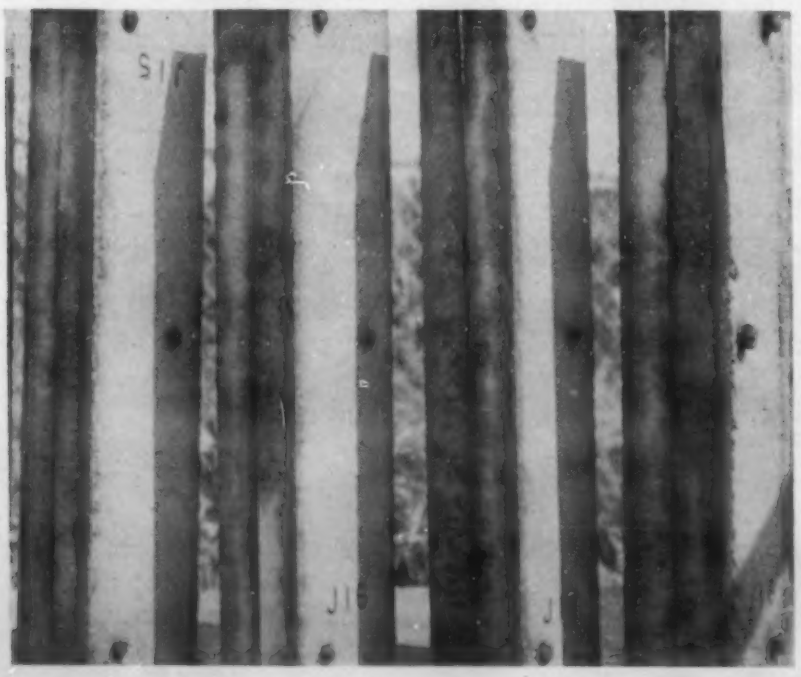


Fig. 1. Painted 17S-T Structural Shapes After 2 Years 8 Months Exposure at Sea Coast. All received two coats of aluminum paint made with long oil varnish over following priming coats (left to right)—red lead, zinc chromate (oil base), basic lead chromate, and iron oxide-zinc chromate primers. [Edwards and Wray paper.]

iron, etching it, and hydrogen is evolved. The oxidizing agent reacts with the hydrogen and takes the hydrogen film off the metal, allowing ferrous phosphate to be adherently deposited on the metal. A suitable coating, of proper texture to take paint well, is said to show about 0.0132 grams P_2O_5 per sq. ft. The phosphate coating is alleged to inhibit the spreading of rust if the paint film is scratched. The discussion is limited to the phosphate with coating and does not deal with the effect of composition of the steel itself, with primers containing inhibitors, or with pigments and vehicles for cover coats. The painting of bare iron is not thoroughly discussed in this series of papers.

Another recent article by Hasson[1], however, discusses these problems and stresses the value of basic lead chromate as a priming coat on steel for actual inhibition of corrosion. Several advantages over the usual red lead primer are listed. Sublimed blue lead is also given a good rating. For a primer over a galvanized coating, a zinc-dust, zinc-oxide paint is approvingly mentioned.

Fig. 2. Painted Steel Structural Shapes After 2 Years 8 Months Exposure at Sea Coast. All received two coats of aluminum paint made with long oil varnish over following priming coats (left to right)—red lead, zinc chromate (oil base), basic lead chromate, and iron oxide-zinc chromate primers. [Edwards and Wray paper.]



Painting of Zinc and Zinc Alloys

Nelson, also, dealt with the painting of galvanized steel. He points out that heavy zinc coatings with matte surfaces, free from glossy spangles, give little trouble, while the smooth spangles require treatment. (Since the spangles will be covered up by paint anyhow, it is obvious that galvanized material to be painted should avoid the finish that makers usually try to give it.)

The smoothly spangled material can (1) be given light sand blasting (sharp grit, 50 to 90 mesh), (2) be etched with an acidulated toluyl-alcohol-carbon tetrachloride mixture (See *Jour. Ind. & Eng. Chem.*, January, 1933, page 27) and be thoroughly washed, or (3) be allowed to weather for three to six months.

In painting zinc-base die castings, initial adherence is easy enough to secure, but permanent adherence is not so easy. Nelson suggests that in a mixture of oils, resins and thinners, found in the usual paint vehicles, selective adsorption may occur (much as is postulated in the case of the adsorption by a bearing metal of the film-forming constituents of a lubricating oil) and in a mixture of long and short chain organic acids, the short-chain ones will be the most active and be adsorbed first so that the "weaker stuff" may be concentrated at the metal surface. It is even suggested that zinc dust, in a primer for painting zinc, may help to take up the compounds that are not wanted and allow a higher concentration of the good ones on the metal surface itself than would otherwise occur.

A straight resin-free nitrocellulose lacquer has poor adherence on zinc, perhaps because the thinners are more polar than the lacquer itself and thus a film of thinner is held on the zinc surface. A metal primer should contain a preponderance of definitely polar long-chain compounds. A primer vehicle with a long chain polymer containing a carboxyl group at the end, with other points of polarity distributed through the molecule, seems indicated.

Baking of a primer tends to polymerize the entire vehicle and knits the whole layer onto the oriented film attached to the metal. It also avoids the stages of oxidation occurring in air-drying, that produce moisture, acids and peroxides in the film. The peroxides are hydrogen depolarizers and hence increase cathodic corrosion, as Kittleberger explained. Zinc dust in the primer reacts with hydrogen and represses its discharge on the metal itself. Chromate primers are not discussed.

Painting of Aluminum and Its Alloys

Edwards and Wray favor zinc chromate in the primer coat to go on over aluminum and its alloys, and top coats of good moisture impedance, made with leafing aluminum flake pigment. They point out that real adhesion between metal and primer is not necessarily predicated upon roughness. Toe-holds count chiefly after the true adhesive bond has been broken. The forces that hold paint to metal act through very small molecular distances. Hence even a slight disturbance at the metal surface spoils the bond. A chemical reaction, such as is produced by moisture, with the release of alkalinity, will injure the bond. Alkalinity is most readily produced on aluminum alloys that contain magnesium. (The same thing happens to a greater extent on pure magnesium or cadium surfaces.) Magnesium combined with Zn as $MgZn_2$ or with Si Mg_2Si is more reactive than Mg in solid solution in Al.

A suitably textured anodic oxide coating on Al is readily repaired by the presence of chromate, so that the best metal-paint combination is a pure Al or Al

solid solution surface (strong alloys can be made as "Alclad" with an Al surface) anodized, primed with zinc chromate, and covered with leafing, moisture-resistant Al pigmented paint, in a synthetic resin varnish vehicle.

Repainting should be done before the old paint is in bad shape. Scratch brushing, washing with warm 5 per cent potassium dichromate solution, to penetrate any pits and render harmless any salts held therein, and coating with zinc chromate primer and two aluminum flake top coats, all in synthetic resin, is advocated on non-anodized surfaces. Solvent removal of the old paint is preferable on anodized Al.

Sometimes treatment of an Al surface with weak phosphoric acid allows good adhesion of paint, this is explained on the basis of the insolubility of aluminum phosphate.

Painting of Magnesium Alloys

The comments on magnesium as an alloy addition in aluminum made by Edwards and Wray prepare one for the discussion of magnesium itself by Winston, Reid and Gross. They note that "alkaline peeling" occurs on Zn, Cd, and Mg, from moisture penetration through the paint film and attack on the metal, producing alkali which in turn attacks the paint at the interface.

Mechanical roughening does not appreciably increase adhesion on Mg, as shown by a bend test. Weathering is not helpful. Other metal coatings are harmful rather than helpful. Phosphate treatment is good for a rigid object, like a casting, not so good for sheet. Silenious acid has been used, but the usual treatment is a pickle in a nitric acid-sodium dichromate solution which produces an etch and a matt gray to yellowish red iridescent coating.

A bright yellow coating produced in old pickling baths with too little dichromate does not give as good adhesion. Of all the pigments tried, only zinc chromate gave real inhibition. Some others were neutral and several definitely corrosive.

The paints studied showed very different results on adhesion, and the variations seemed to be much more dependent on the pigment than on the vehicle.

Baked vinyl resin was rated good in hardness, adhesion and imperviousness.

Less complex treatments will serve for less severe service, but for use in continuously moist air or in marine service, zinc chromate primer, a surfacing coat for smoothness if desired, and two or three coats of aluminum-pigmented varnish, all in phenolic bases, and all coats baked, are suggested.

Except that successful anodizing of Mg has not yet been accomplished, the conclusions as to the painting of Mg are quite similar to those drawn for Al. The conclusions refer to Mg alloys containing Al, Mn, and sometimes Zn.

Painting of Other Metal Products

Apparently those steering this symposium did not consider that stainless steel, nickel and its alloy copper, brass, bronze, lead, or tin and terne-plate are used in the painted condition often enough to justify discussing them. Nevertheless, all these have some uses in which, with the advent of modern color-consciousness, painting for a decorative effect in contrast, or in some cases, for protection, may be required.

There is an auxiliary problem in regard to copper, for the run-off from copper screens, for example, may stain paint, and there is a difference in the susceptibility of paints to such staining. Copper roofs, used for permanence, go through an unsightly tarnished stage before natural patina appears, and while this problem is being attacked on the basis of the rapid production of artificial patina the painting problem may be present with copper.

According to the Copper and Brass Research Association[2], a copper roof, for example, is scrubbed with strong NaOH solution and washed with hot, then with cold water, brushed with a solution of 8 oz. copper sulphate, ¼ oz. nitric acid to the gallon, allowed to dry, dusted off with a dry brush and painted with a red lead priming coat followed by at least two coats of white lead in linseed oil plus the desired color.

Terne-plate roofs are usually painted, but it is probable that this is one of the least difficult of metal-painting jobs, for lithographed cans, either of tin or terne plate may be made with ease. In fact, multicolor

Fig. 3. Painted 17S-T and Steel After 13 Weeks Complete Immersion in Black Rock Harbor, Conn. Panel on left, of 17S-T, with 2 coats of primer followed by anti-corrosive and anti-fouling paints. Most of anti-fouling paint (dark areas) weathered off but no apparent corrosion or barnacle growth. Steel panel in center, finished in same manner, shows considerable rusting, especially at edges; rusted completely through in one hole near lower left corner. Panel on right, also of 17S-T, finished in similar manner but primer allowed poorer adhesion of anti-fouling paint—hence some barnacle growth has taken place—No corrosion. [Edwards and Wray paper.]

printing on clean, well de-greased, tin or terne plate is done as readily as on paper, and the coatings show remarkable adhesion, forming and stamping being possible after coating. No roughening or etching is required. One wonders whether this is not related to the specific adsorptive power of tin (shown by the ability of a tin base babbitt to function as a bearing metal) to hold polar compounds, as discussed by Nelson for zinc.

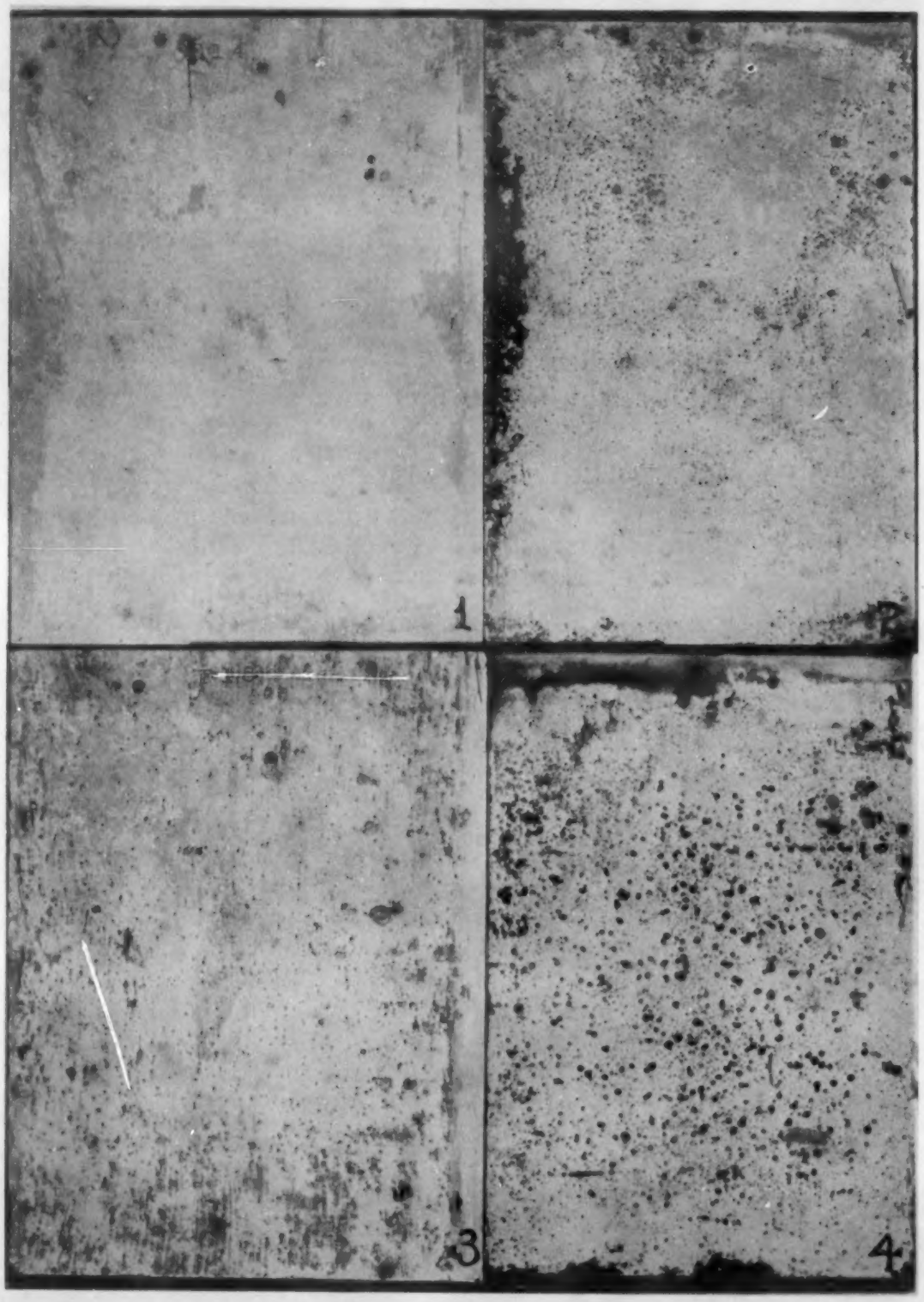


Fig. 4. Gray Painted 17S-T and Steel Panels After 13 Weeks Alternate Immersion in Black Rock Harbor, Conn.; Top Row, Aluminum Paint Primer, Bottom Row, Navy Red Lead Primer. Panel 1, of 17S-T, shows some weathering of gray top coats but very little corrosion; panel 2, of steel, having the same primer, shows numerous pin point rust pits with considerable rust at left edge; panel 3 of 17S-T shows moderate weathering of gray top coats and scattered pin point corrosion spots; panel 4, of steel, having the same primer, shows rather severe rust pitting all over surface. [Edwards and Wray paper.]

Conclusions

The whole series of papers brings out pretty clearly the permeability of all organic coatings of the paint, varnish and lacquer type for moisture and oxygen, to reduce which aluminum-pigmented coatings are used and to nullify the effects of which some metallic compound, exemplified by zinc chromate, is advisable in the primer coat. Thus there seems little chance of any clear, non-pigmented coating being truly permanent on metals, unless the metal itself is entirely non-reactive with moisture and air. For exterior service, where copper is to be protected from tarnish, or matte stainless steel is to be more readily washable, clear vitreous enamels seem indicated.

In view of the difficulties from the perviousness of organic coatings, vitreous enameling will doubtless continue its present marked progress. One large scale application of vitreous enameling, that of the A. O. Smith Corp. on pipe, purely for protection, may presage analogous applications to structural steel, once and for all, prior to erection, instead of repeated painting. Accidental damage to the enamel will, of course, cause minor difficulties. In the case of Al, Mg and Zn, organic coatings will persist unless a sufficiently fusible vitreous enamel is made available, and its development is a difficult, if not an impossible, task.

There is a field, not touched upon in this series of papers, in the development of alloy steels which can, more readily than carbon steel, be given a surface that will satisfactorily take paint, either naturally or by some special chemical treatment to produce a "primed surface," or which will react better with the inhibiting ingredients in a separately applied priming coat.

How many steel makers have given proper alloying, proper surface treatment, and proper priming and cover coats, as much thought as the Dow Chemical Co. has given to those factors in the protection of magnesium?

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[1] Hasson, J. O. "Improved Paints Spur Attacks on Corrosion Problems," *Steel*, Vol. 96, March 11, 1935, pages 30 to 33.
[2] "Sheet Copper," Handbook for Architects and Sheet Metal Workers, 1932.

1. ORE CONCENTRATION

JOHN ATTWOOD, SECTION EDITOR

Enriching Rhodes Chromite (Studio sull'arricchimento delle Cromiti di Rodi). ERNESTO SALMOIRAGHI. *Annali di chimica applicata*, Vol. 25, May 1935, pages 243-254. Chromite from the Isle of Rhodes is enriched by flotation, as well as with the use of electromagnets. In order to use the flotation method successfully, the ore must be first crushed and screened to less than 3000/cm.² mesh, in order to liberate the Cr_2O_3 from encrusting material. AWC (1)

Tailing from the Boston-Richardson Mine, Nova Scotia. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 56-59. Table concentration of a tailing assaying Au 0.11 oz./ton and As 2.11% gave only 60% recovery of the Au. Flotation followed by table concentration will recover 90-95% of the Au. Ball milling of the tailing brightens the sulphides so that they float more readily. The concentrates cyanide easily to give 90% overall extraction. AHE (1)

Gold Ore from Kirkland Gold Belt Mines, King Kirkland, Ont. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 79-86. The ore assays Au 0.33 oz. and Ag 0.60 oz./ton; the Au is largely associated with pyrite. Amalgamation is not satisfactory. Cyanidation of ore ground 95% —200 mesh for 24 hours recovered 87.8% of the Au. Tabling the tailing gave a pyrite concentrate, which when reground and agitated in cyanide solution for 48 hours gave an overall recovery of almost 90%. AHE (1)

Gold Ore from Demara Mines, Limited, Barraute, Quebec. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, pages 71-74. The ore assays Au 0.34 and Ag 0.28 oz./ton, Cu 0.43 and As 0.02%. Amalgamation recovers 71% of the Au at —48 mesh and 75% at 82% —200 mesh. Cyanide consumption was high due to the Cu. Flotation recovers 84% of the Au in a high-grade concentrate. Cyanidation of the flotation tailing gives an overall recovery of 97%. AHE (1)

Gold Ore from Alcona Gold Mines, Limited, Alcona, Ontario. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 112-121. All-cyanidation or cyanidation followed by amalgamation are unsatisfactory for treatment of this ore assaying Au 1.20 oz. and Ag 4.14 oz./ton, Cu 0.27, Pb 1.71, Zn 0.39, Fe 4.36, and S 3.16%. Concentration and regrinding of the sulfides in an all cyanide flowsheet improves extraction but not enough to produce a good tailing. Best practice calls for grinding the ore 95% —200 mesh, taking off a high grade flotation concentrate for smelter sale after barrel amalgamation, and cyaniding the flotation tailing. Except for Cu, recovery of each metal is more than 90%. The cyanide tailing assaying Au 0.01 oz./ton can be produced in 24 hours with KCN consumption of 0.40 lb./ton. AHE (1)

The Canadian Matachewan Gold Mines, Limited, Matachewan, Ontario. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 13-21. With an ore containing 0.205-0.23 oz. Au/ton, overall recovery by flotation and cyanidation of the concentrate was 86-88%; by cyanidation and regrinding and cyaniding the concentrate obtained by tabling in cyanide solution, recovery of about 95% is possible. AHE (1)

Antimonial Gold-Silver Ore from Tatlayoco Lake District, British Columbia. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 22-24. A complicated flow sheet (probably not practical) is suggested for treating a very refractory ore assaying Au 0.925 oz. and Ag 15.26 oz./ton, As 3.90% and Sb 9.70%. AHE (1)

Manganese Vein on Gowland Mountain, Albert County, N. B. W. J. WRIGHT. *Canadian Mining & Metallurgical Bulletin* No. 278, June 1935, pages 282-287. There are 2 types of ore: (1) Mn 50.62, Fe 0.30 and SiO_2 15.00%, (2) Mn 24.69 and Fe 3.00%. Concentration of (2) gives a 50% Mn concentrate at 50% recovery, or a 40% grade at 60% recovery. AHE (1)

Platinum Content of Minerals of Sulphidic Ores. O. E. ZVIAGINTZEV & A. N. FILIPPOV. *Doklady akademii nauk SSSR*, New Series, Vol. 3, Jan. 21, 1935, pages 136-137. In Russian. German translation on pages 138-139. Pt present in sulphide ores associates preferably with galenite and sphalerite and is never present in pyrite nor in minerals not containing heavy metals. The preference of Pt for Pb is surprising and lacks theoretical justification. Occasionally Pt is present in ores not containing Pb, as shown by the analyses of 4 Cu ores from the Buron deposits (Northern Caucasus). ORS (1)

Auriferous Black Sands of the Pacific Coast. EDMUND S. LEAVER. *Progress Report—Metallurgical Division. 11. Studies on the Recovery of Gold and Silver. United States Bureau of Mines, Report of Investigations* No. 3275, June 1935, pages 51-54. Methods for recovery of Au and Pt from black sands are described briefly. 15 references. AHE (1)

The Concentration of Tin Ores. I, II. A Survey of Modern Trends and Practice. W. H. CROPP. *Chemical Engineering & Mining Review*, Vol. 27, May 8, 1935, pages 271-274; June 8, 1935, pages 308-314. A general report of progress in each of the major flowsheet operations. WHB (1)

Some Developments in Ore Pulp Classification. D. MACLEAN & C. L. DEWAR. *Journal Chemical, Metallurgical & Mining Society of South Africa*, Vol. 35, May 1935, pages 329-343. The advent of stage tube milling on the Rand has intensified interest in classification. The methods in use are (a) the cone classifier, and (b) a mechanical classifier (Dorr type); (a) has not been satisfactory. A mechanically operated gear for increasing and controlling underflow from primary cone classifiers is described; operating results are satisfactory. A new classifier is described. Pulp is fed tangentially at the edge of a shallow bowl with an inverted truncated cone in the center. Underflow is raked spirally up the cone and discharges in the center. The principles controlling its operation are discussed and operating data given. AHE (1)

Recent Developments in Gold Milling Practice. W. B. TIMM. *Transactions Canadian Institute of Mining & Metallurgy*, 1935 (in *Canadian Mining & Metallurgy Bulletin* No. 280, Aug.), pages 330-340. Developments in Nova Scotia, Quebec, Ontario, Manitoba, and British Columbia are reviewed. The outstanding developments and improvements in Au milling practice are: (1) Adaptation of the Hadsel mill, (2) introduction of Symonds cone crusher, especially the short-head type, for secondary or tertiary stage crushing, (3) use of Newhouse crusher as a secondary crusher, (4) tendency of larger plants to crush finer, at least ⅜", before grinding, (5) introduction of Hardinge classifier as a primary classifier, (6) use of heavy-duty Dorr FX classifier to increase circulating loads, (7) increased use of the Akins submerged-type of classifier in competion with the Dorr classifiers, (8) introduction of the Quad F type bowl classifier as a secondary classifier in circuit with tube mills, (9) use of the shallow thickener, with under-driven rakes, as a classifier for extremely fine-divided pulps, (10) use of the unit flotation cell or jigs or hydraulic cone traps for the concentration of Au between the ball mill and classifier, (11) extended use of corduroy blanket tables for recovery of Au before cyanidation or flotation, (12) conditioning of pulps containing pyrrhotite and other cyanicides by air before cyanidation, (13) development of the string filter and its use for filtering finely divided ore pulps, and (14) development of the Merrill-Crowe units of simultaneous clarification and precipitation for small cyanide plants. AHE (1)

Copper Ore from Ventures, Limited, Opemiska Lake, Quebec. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 122-125. Tabling of an ore containing Cu 10.66% and Au 0.125 oz./ton recovered 69.5% of the Cu and 72.1% of the Au in a concentrate assaying 15.80% Cu and 0.22 oz. Au/ton. Flotation of the reground tailing recovered 94% of the Cu and 87% of the Au to give an overall recovery of 98.2% of the Cu and 96.4% of the Au. The flotation concentrate assayed 31.50% Cu and 0.36 oz. Au/ton. AHE (1)

Gold Ore from Gunville Claims, Manitoba. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 126-128. Amalgamation at —100 mesh of an ore containing 0.155 oz. Au/ton and 0.02 oz. Ag recovered 84% of the Au. Cyanidation of —48 mesh ore recovered 96.8% of the Au; finer grinding did not increase extraction. Flotation of —200 mesh ore recovered 86% of the Au. AHE (1)

Gold Ore from the Manley Mine, Near Dupuy, Quebec. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 139-144. The ore assayed Au 1.44 and Ag 2.92 oz./ton, Te 0.01, W 0.22, Pb 0.22, Cu 0.23, and Zn 0.05%. Cyanidation recovers 94.8% of the Au at —150 mesh with 48 hours agitation. Despite this good recovery, the tailing contains 0.075 oz. Au/ton. Amalgamation recovers only 59% of the Au. Flotation recovers 85% of the Au. Cyanidation of the tailing gives an 0.01 oz. tailing and an overall recovery of 99.34%. AHE (1)

Gold Ore from Meridan Mining Company, Limited, Camborne, British Columbia. W. B. TIMM *et al. Canada Department of Mines, Mines Branch Report* 744, 1934, pages 129-132. Flotation or cyanidation will give high recovery from an ore assaying Au 0.66 oz. and Ag 0.42 oz./ton, Pb 0.26, Cu 0.01, Zn 0.28, SiO_2 89.2, Fe 2.5 and S 0.76%. For cyanidation, 30 hrs. agitation of an ore 60% —200 mesh is recommended. AHE (1)

1a. Crushing, Grinding & Plant Handling

Roasting and Agglomeration of Ores in a Turbulent Flow Furnace (Grillage et agglomération des minerais au four à turbulence). MARCEL FOURMENT. *Revue de Métallurgie*, Vol. 32, June 1935, pages 245-247. Saint-Jacques furnace consists of a vertical refractory lined cylinder. Ore to be roasted or agglomerated is introduced in the center at the top, the heat is supplied at the bottom through tangentially located burners. The ore remains in suspension up to the moment when it settles in incandescent state at the bottom on already deposited particles to which it fuses. This flash roasting produces porous and strong agglomerate suitable for blast furnace use. Thermal efficiency is increased by the use of recuperators. The furnace installed in the East of France works on blast furnace dust and iron ore operating at 1400° C. and consuming coke oven gas. JDG (1a)

Some Phases of Eagle-Picher's Central Milling Project. R. J. STROUP. *Mining Congress Journal*, Vol. 21, Sept. 1935, pages 62-65. Since 1932 about 30 milling plants for Pb and Zn ores in the Tri-State district have been dismantled and replaced by large central plants, permitting more efficient concentration. The article discusses the various problems in handling the ore from mine to mill, how they have been solved, and the resulting decrease in cost and increase in efficiency. Gives details of elaborate sampling system made necessary by the change in operation. BHS (1a)

1b. Gravity Concentration

Mining and Milling Tungsten Ores. WM. O. VANDERBURG. *United States Bureau of Mines, Information Circular* No. 6852, Sept. 1935, 47 pages. Concentration of W ores depends basically on gravity methods. Under normal conditions W concentrates must contain at least 60% WO_3 and be virtually free from S, P, As, Sb, Bi, Cu, Sn and Mo. Crushing and grinding, classification, jigging, tabling, slime treatment, dewatering, roasting, magnetic separation, centrifugal concentration, pneumatic concentration, and flotation are described briefly. The operations of 5 concentrators are described and their flow sheets shown. AHE (1b)

1c. Flotation

Some Problems of Gold Flotation. Kellogg Krebs. *Mining & Metallurgy*, Vol. 16, Sec. 1, May 1935, page 225. From paper read before the San Francisco section of the American Institute of Mining Engineers. There are numerous successful examples of Au ore flotation in regions of western United States where oxidation is limited and minerals are primarily in form of crystalloids. Study of tailings of an auriferous ore that was classified as amenable to flotation shows major losses to be in coarser particles, mostly in middling and in true slime. In cases of oxidized ores having colloid content, absorption of gangue lime is major cause of difficult free Au flotation. Flotation is ideal process to condition feed for cyanide operation, since it recovers Au that is most difficult to recover by cyanidation. VSP (1c)

1

Copper-Nickel Ore from Calumet Island, Pontiac County, Quebec. *Canadian Department of Mines, Mines Branch Report* No. 743, 1934, pages 127-129. The ore analyzed Ni 0.88, Cu 0.17, Co none, Fe 18.8, S 9.87, insoluble matter 54.9%, Au 0.02 oz./ton and Ag 0.055 oz./ton. Extensive surface alteration of the ore resulted in low recoveries by flotation, 60-67% of the Ni and 72-78% of the Cu in a concentrate assaying 5% Ni and 1.3% Cu. Increasing xanthate improves Ni recovery to a limited extent. AHE (1c)

Molybdenite Ore from Pigeon Lake, Gloucester County, New Brunswick. *Canadian Department of Mines, Mines Branch Report* No. 743, 1934, pages 130-131. A concentrate assaying 85-90% MoS_2 can be produced by flotation of an ore assaying 5.02% MoS_2; recovery is high. AHE (1c)

The Dentonia Flotation Mill. W. Holdsworth. *Transactions Canadian Institute of Mining & Metallurgy, 1935* (*in Canadian Mining & Metallurgical Bulletin* No. 276, Apr.) pages 134-139. An average analysis of the Dentonia ore is Au 0.27 oz. and Ag 1.73 oz./ton. Cu 0.12%, Pb 0.31%, and Zn trace. The average assay of the concentrate from flotation is Au 6.5 oz. and Ag 45.0 oz./ton; the middlings average Au 1.5 oz. and Ag 9.7 oz./ton. The reagents used are soda ash 3.0 lb., aerofloat 0.15 lb. and reagent No. 301 (a higher xanthate) 0.35 lb./ton. AHE (1c)

History of Flin Flon Mine up to Construction. R. E. Phelan. *Transactions Canadian Institute of Mining & Metallurgy*, 1935 (in *Canadian Mining & Metallurgical Bulletin* No. 275, Mar.) pages 55-70. The ore contains Au 0.074 oz., Ag 1.06 oz./ton, Cu 1.71%, Zn 3.45%, large amounts of S and Fe, and traces of Pb, As, Sb, Co, etc. Experimental work on the extraction of the values is described. A sulphating roast followed by leaching, electrolysis, purification, etc. (details given) failed because $MgSO_4$ built up in the circuit. Bulk flotation left all the Mg in the tailings, and opened the way for successful roasting and leaching. But, in bulk flotation, the minerals were recovered in a definite order, so selective flotation was attempted. A Cu concentrate and a Zn concentrate were made in a 2-ton mill, followed by cyanidation of the tails. Operation of a pilot mill was successful at times, then went wild due to talc. Talc was removed by prior flotation with pine oil without any collector. Results were satisfactory. AHE (1c)

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New Flotation Reagents. R. S. Dean & A. B. Hersberger. *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 605, Feb. 1935, 10 pages. The behavior of certain long-C-chain organic compounds with extreme lypophile hydrophile unbalance was studied in flotation circuits. These compounds, represented typically by the sulphuric-acid esters of fatty-acid derivatives, possess marked frothing and emulsifying powers that are affected to only a slight extent by acids, alkalis, and salts. They are good frothers with virtually no collecting power. Their great emulsifying power permits the use of insoluble lypophilic substances, such as paraffin oil, as collectors. Compounds having only moderate hydrophile unbalance are very selective collectors. Results are given for the flotation of a number of ores using Emulsol X-1 reagent, which is a mixture of a number of compounds having extreme hydrophile lypophile unbalance, as a frothing agent, and oleic acids, modified oleic acids, and insoluble oils as collectors. JLG (1c)

6

Flotation of Unclassified Ball Mill Discharge for the Recovery of the Lead and Zinc Concentrates. J. E. Garrett. *Proceedings Australasian Institute of Mining & Metallurgy* No. 92, Dec. 31, 1933, pages 475-499; No. 94, June 1934, pages 69-79. The sulphide ore at North Mine, Broken Hill, is classified into a granular and a fine product and floated. Laboratory and mill experiments showed that the size separation was unnecessary. In the experimental mill run, reagents in the Pb flotation were K xanthate 0.04, eucalyptus oil 0.02, and soda ash 0.075 lb./ton. The Pb concentrate assayed Pb 73.75 and Zn 4.7%. A flow sheet is proposed. Alkalinity of H_2O should be kept at 0.002% Na_2CO_3 equivalent. AHE (1c)

7

A Corrosion-Proof Reagent Feeder. J. P. Lawyer. *Engineering & Mining Journal*, Vol. 136, May 1935, page 241. An illustrated description of a corrosion-proof flotation reagent feeder. It can be adjusted from 30 cc./min. up. WHB (1c)

Significance of the Time of Contact Between Mineral and Air Bubble During Flotation (Bedeutung der Berührungszeit zwischen Mineral und Luftblase bei der Flotation). Invar Sven-Nilsson. *Kolloid Zeitschrift*, Vol. 69, Nov. 1934, pages 230-232; *Ingeniörs Vetenskaps Akademiens Handlingar* No. 133, 1935, 24 pages. In German. An air bubble was brought into contact with the surface of mineral particles for short (0.02 sec.) or long times. For an air bubble to adhere to the mineral, a definite minimum of time of contact is required; this is the so-called induction period which has an important bearing on the flotation process. Induction periods vary considerably (~ 0.1 sec. to 1 day) and depend partly on the bubble size and partly, though to a lesser degree, on the pretreatment of the mineral surface. Smaller bubble sizes shorten the induction periods. Flotation tests are graphically presented showing the effect of K-xanthogenate, KCN, $K_2Cr_2O_7$, on pyrite, galena, chalcopyrite, Au, and Pt. Former practical experience on the 3 ores is confirmed, and the important rôle of the induction period is clearly brought out. EF (1c)

8

Flotation Widely Employed in San Juan Milling. Charles A. Chase. *Engineering & Mining Journal*, Vol. 136, Aug. 1935, pages 395-397. The custom plant of Shenondoah-Dives near Silverton has a capacity of 600 tons/day. Bulk flotation is employed. A flowsheet is shown. WHB (1c)

Climax—Premier Producer of Molybdenum. W. J. Coulter. *Engineering & Mining Journal*, Vol. 136, Aug. 1935, pages 401, 404. Ore reserves are huge. Flotation is used in the concentrator and the operating basis is 4000 tons/day. WHB (1c)

New Flotation Plant of Broken Hill South. *Chemical Engineering & Mining Review*, Vol. 27, June 8, 1935, page 304. A new Pb and Zn flotation plant with a weekly capacity of 8,000 tons has started operation. Individual, wedge-rope drive to each impeller features the installation. Power consumption has been reduced by 37%, the grade of both Pb and Zn concentrates improved and metal recoveries are higher. Maintenance will be considerably decreased with labor unchanged. WHB (1c)

Analysis of Sedimentation Experiments (Analyse des Essais de Sedimentation). P. Debye. *Revue Universelle des Mines*, Vol. 11, June 1935, pages 266-268. Particle size of fine powders can be determined by dielectric measurements made on a suspension in a non-conducting liquid. Ha (1c)

Silver Ore from Kozak Mine, Goudreau, Ontario. W. B. Timm *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 54-55. The ore, containing 0.13 oz. Au and 5.19 oz. Ag/ton, was easy to crush and yielded without difficulty a flotation concentrate assaying Au 4.17 oz. and Ag 163.64 oz./ton. AHE (1c)

Lead Ore from Godfrey, Ontario. W. B. Timm *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 68-70. A concentrate containing more than 75% Pb with a recovery of 98% of the Pb can be obtained easily by flotation of an ore assaying Au nil, Ag 0.16 oz./ton, Cu 0.04, Zn 0.60 and Pb 12.64%. AHE (1c)

Copper-Nickel Ore from the Cuniptan Mines Development Co., Ltd., Strathy Township, Temagami Forest Reserve, Ont. W. B. Timm *et al. Canada Department of Mines, Mines Branch Report* No. 744, 1934, pages 87-88. The ore assays Au 0.055 and Pt 0.625 oz./ton, Cu 7.14, Ni 2.88 and Zn 5.30%. Flotation recovered 55% of the Au, 92% of the Pt, 99% of the Cu, 82% of the Ni and 84% of the Zn. The sample was badly oxidized; better results could be obtained on fresh ore. AHE (1c)

1d. Magnetic Separation

Grain Size of Highly Magnetic Ore Subjected to Concentration and Choice of the Type of Separator. V. G. Derkac. *Gornuiy zhurnal*, Vol. 111 (New Series, Vol. 18), No. 1, Jan. 1935, pages 70-71. In Russian. Upon separation of highly magnetic iron ore in a conventional drum-type magnetic separator the share of gangue in the product increases with decreasing grain size of the ore. An experimental study of the behavior of individual ore grains on the drum of a separator with a radial magnetic system indicated that the separation becomes more complete as the number of magnetic poles is increased. It is recommended for efficient separation of fine-grained ore to use a drum-type separator with a radial magnetic system, the number of magnetic poles increasing with decreasing grain size of the ore; and of ore with a grain size larger than 12-15 mm.—a drum-type separator with a sectorial magnetic system or a disc-type separator. ORS (1d)

1e. Amalgamation, Cyanidation & Leaching

Form and Occurrence of Gold in Pyrite from a Metallurgical Standpoint—Coated Gold. R. E. Head. *Progress Report—Metallurgical Division. 11. Studies on the Recovery of Gold and Silver. United States Bureau of Mines, Report of Investigations* No. 3275, June 1935, pages 39-46. Au particles isolated from refractory ores commonly are coated. Particles with surface contaminations are more abundant in partly oxidized pyrite. Since coated Au particles have been identified constantly in amalgamation and cyanidation tailings, the failure to effect recovery has been blamed on the coatings. Spectroscopic examination of coatings show the presence of Fe, Ag, Pb, Mn, Al, and Ti. AHE (1e)

Treatment of Leucite so as to Extract Potash and Alumina Simultaneously (Le traitement de leucite en vue d'en extraire à la fois la potasse et l'alumine). *Génie Civil*, Vol. 106, May 1935, pages 517-518. Description of a method used in an experimental plant given by Gaetano Castelli, *Industria Mineraria*, Nov.-Dec. 1934. Leucite is treated with a solution of NaCl according to the reaction $K_2OAl_2O_34SiO_2+NaCl=2KCl+Na_2OAl_2O_34SiO_2$. The insoluble compound formed is filtered off and calcined in a rotary furnace with limestone. The reaction occurring is: $Na_2OAl_2O_34SiO_2+4CaCO_3=4CaSiO_3+Na_2OAl_2O_3+4CO_2$. The mixture is leached with water and Al $(OH)_3$ precipitated with CO_2 produced in calcining. JDG (1e)

Mill and Milling, Carson Hill Gold Mining Corporation. Charles H. Segerstrom. *Mining Congress Journal*, Vol. 21, Sept. 1935, pages 51-54. Daily capacity of the mill is in excess of 650 tons of ore; this will be raised to 1,000 tons in the near future. Recovery of gold effected by amalgamation and cyanidation. Stamps are used for intermediate crushing, followed by fine grinding in Hardinge pebble mills. Reciprocating tables are used to concentrate the gold-bearing sulphides preliminary to regrinding and amalgamation of the finely ground sulphides which then join the table tailings for final treatment by cyanidation. Ore consists of quartz and schist, carrying free gold with 3% sulphides. Total recovery from 88% up, with a total milling cost of $0.56 per ton of ore. Tailings to waste assay about $0.22 per ton. BHS (1e)

9

10

2. ORE REDUCTION

A. H. EMERY, SECTION EDITOR

Metallographic Viewpoints on Powder Metallurgy with Special Reference to Hardened Metals (Metallografiska synpunkter pa pulvermetallurgien, speciellt hard-metalltillverkningen). GÖSTA STERKY. *Jernkontorets Annaler*, Vol. 119, July 1935, pages 255-280. General review. HCD (2)

2a. Non-Ferrous

Contributions to the Data on Theoretical Metallurgy. III. The Free Energies of Vaporization and Vapor Pressures of Inorganic Substances. K. K. KELLEY. *United States Bureau of Mines, Bulletin* No. 383, 1935, 132 pages. The previously compiled entropy values (*Metals & Alloys*, Vol. 4, Mar. 1933, page MA 83) and specific heat equations (*Metals & Alloys*, Vol. 5, Dec. 1934, page MA 555) are applied to vapor pressure and other pertinent data in obtaining heat and free energy of vaporization equations for inorganic substances valid up to the normal boling point or sublimation point at 760 mm. pressure. Wherever possible, data on heats and entropies of transformations and fusions and entropies of gases are supplemented. Tables of vapor pressures for 242 inorganic substances are summarized from the detailed discussion. 454 references. AHE (2a)

Smelting in the Lead Blast Furnace—Handling Zinciferous Charges. G. L. OLDRIGHT & VIRGIL MILLER. *Metal Industry*, London, Vol. 45, Dec. 28, 1934, pages 611-612; Vol. 46, Jan. 4, 1935, pages 7-10. See *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 1. HBG (2a)

Working of Electrolytic Baths with an Increased Alumina Charge. A. I. SHELEZNOV & B. N. MAXIMENKO. *Legkie Metalli*, May 1935, pages 4-8. In Russian. To reduce anode effect to about 2 in a day the Al_2O_3 content of 2 production furnaces was increased to 10%. A run of 3½ months was studied. Their average yield was greater than the production average. Anode consumption was 638 kg./ton of Al as compared with 732 kg./ton of Al of the usual production practice. Cryolite consumption was 5 kg. less per ton of Al. (2a)

Ancient and Present Smelting Processes in the Field of Sulphur Production (Hüttenkunst von einst und heute auf dem Gebiete der Schwefelgewinnung). J. EDER. *Montanistische Rundschau*, Vol. 27, Aug. 16, 1935, pages 1-4. Reviews the medieval processes for extraction of S from sulphide ores, as described by Agricola and other chemists of that period. Most of these processes consisted in roasting, followed by reduction with carbonaceous matter. Among modern methods are the Tylox procedure, in which the sulphide ore is first treated with acid to give H_2S which is absorbed in alkaline arsenate. Free S is then obtained by blowing air through this solution. One of the latest processes is the Norwegian Orkla process, in which a mixture of pyrite, coke, quartz, and lime is melted in a blast furnace, where the S is volatilized while Fe goes into the slag. Only 2% of the S is lost in the form of oxide in this process. The temperature of the furnace is about 1,600° C. About 60,000 tons S annually is produced by this process. In a recent Russian process a pyritic flotation concentrate is melted in blast furnace; as the sulphides of Fe melt they sink to the lower part of the furnace where they are oxidized. The escaping fumes of S are caught in filters and condensers, while SO_2 and SO_3 are worked into H_2SO_4. BHS (2a)

The Flin Flon Copper Smelter of the Hudson Bay Mining & Smelting Co., Limited. J. H. AMBROSE. *Transactions Canadian Institute of Mining & Metallurgy, 1935 (in Canadian Mining & Metallurgical Bulletin* No. 281, Sept.) pages 402-420. The smelter equipment consists of 3 Nichols-Herreshoff roasters, 1 reverberatory furnace, 2 Peirce-Smith converters, a Walker casting wheel, and a 4 unit Cottrell plant, 2 units for the roaster gases and 2 for the converter gases. A description of the equipment and operation in each smelter department is given. AHE (2a)

Electrolytic Zinc Plant at Magdeburg (L'usine de zinc électrolytique de Magdebourg). *Journal du Four Electrique*, Vol. 44, July 1935, page 248. Concentrates containing 60-61% Zn, 32-33% S, 1-1.3% Pb, 4% Fe and traces of As, Cd, Cu, Ni and Co are roasted in 4 Humboldt furnaces having a daily capacity 60 tons each. Gases are converted into H_2SO_4 used for dissolving the roasted concentrates. Impurities are precipitated with Zn dust. Electrolysis is conducted in 2 batteries of 240 cells lined with Pb and having 12 Al cathodes and Pb andoes. 20 mm. distant from each other. Zn sold is guaranteed 99.99% pure. JDG (2a)

Oxidation of Carbon in Scum by Atmospheric Oxygen. B. I. IVANOV & B. N. MAXIMENKO. *Legkie Metalli*, May 1935, pages 14-18. In Russian. Carbon scum which is a by-product of Al reduction contains about 5% Al_2O_3, 25% C, the rest being cryolite. To recover the electrolyte C must be eliminated. Methods already proposed involve oxidation at higher temperatures which lead to fusion and loss of the electrolyte. A series of experiments on ignition of the scum in air at 780° C. showed that the C content drops rapidly reaching 0.84% after 80 minutes and 0.24% in 120 minutes. (2a)

Modern Electrolytic Aluminum Plants in Western Europe and America. P. F. ANTIPIN. *Legkie Metallui*, Vol. 4, Mar. 1935, pages 39-50. In Russian. A general description of 8 plants, including 11 illustrations. HWR (2a)

Purification of Mg and Ca by Sublimation (Purification of Mg and Ca par Sublimation). J. HÉRENGUEL & G. CHAUDRON. *Aciers Spéciaux, Métaux et Alliages*, Vol. 9, Oct. 1934, pages 415-417. Purification of Mg by sublimation is carried out at 600°-650° C., the Mg vapors passing through a metallic filter and the metallic Mg (99.99%) condensed at 400° C. under 0.01 vacuum. Ca may be purified in the same manner but in order to separate the Na the metal is heated in A at 800° C.; then the remaining metal is sublimed in vacuum at 800° C. producing 99.5% metal. GTM (2a)

2b. Ferrous

Study of Operation of Zaporojstal Plant Blast Furnaces. M. POZIN & M. SHAPOVALOV. *Domez*, No. 6, 1935, pages 12-25. In Russian. After completion of the plant it was found that the blast furnaces in question were built on loess bottom which caused uneven settling of the foundation and wandering of the vertical axis of the furnace. Deviation of the center line of the charging device from the original reached 150 mm. when the furnace was blown in and after that time moved in all directions. An attempt was made to correlate the defective operation of the furnaces with this phenomenon. Determination of charge distribution by means of feelers made during 5 shifts indicated a pronounced concentration of the charge on the side opposite to the inclination of the vertical axis. It was more pronounced in higher levels than in the lower ones and was connected with the changes in the gap between the bell and hopper due to the swinging of the former with the inclination of the shaft. The non-uniform distribution of the charge leads to filling of the hearth with coke and unreduced materials leading to burning of the tuyeres from below. The latter fact can be associated with the poor quality of coke. Since coke made in this plant began to be used the number of tuyeres burned in a month in both of the furnaces increased from 27 and 34 to 78 and 104 showing a tendency towards a further increase. The number of burnt tuyeres is greater on the side opposite to the inclination of the stack apparently being connected with an improper slag formation in the respective areas induced by uneven distribution. Wind conditions checked during satisfactory and poor operations were identical as to the amount, pressure and temperature. Heating of the lining determined by actual temperature measurements of cooling water and of the lining itself was reasonably uniform, though with a tendency to be greater on the inclined side. No references to the composition of iron produced are given. Unsatisfactory operation of the furnaces is attributed to their one-sided operation to some extent and, principally, to the unsatisfactory quality of coke used. 22 charts and diagrams. (2b)

The Use of Oxygen Enriched Blast in the Blast Furnace (Die Verwendung von sauerstoffangereichertem Gebläsewind im Hochofenbetrieb). W. LENNINGS. *Stahl und Eisen*, Vol. 55, May 16, 1935, pages 533-544; May 23, 1935, pages 565-570. The experiments with O_2 enriched blast were tried to see (1) whether this would lower the fuel cost and (2) whether with the increased temperature obtained, slags high enough in lime could be produced so that they would have the composition of portland cement. O_2 enriched blast reduced the amount of air required, gave higher bosh temperatures, and increased the fuel efficiency. For a daily yield of 50-60 tons of ordinary pig Fe a saving in coke of 100 to 150 kg./ton of pig Fe resulted; the usual coke consumption is about 1000-1150 kg./ton pig Fe. In making ferromanganese the coke consumption is higher and here the saving in coke was 300-400 kg./ton ferromanganese. For pig Fe the blast was enriched to about 24 to 26% O_2; for ferromanganese to about 30% O_2. There were no ill effects on the refractories; there was less loss of Mn to the slag. The use of O_2 enriched blast proved economical for ferromanganese. Slags of the composition of portland cement were produced but the manufacture of portland cement in the blast furnace does not yet appear practicable. SE (2b)

Reducibility of Dwight-Lloyd Sinter and Its Suitability for Charging in the Blast Furnace (Die Reduzierbarkeit von Dwight-Lloyd-Sinter und deren Anpassung an den Erzmöller). KURT GRETHE & JULIUS STOECKER. *Stahl und Eisen*, Vol. 55, June 13, 1935, pages 641-647. The production of a uniform sinter depends on the composition of the raw material and on the permeability of the mix. Fe compounds having a large temperature range between the sintering and melting points favor good sinter. The porosity of the sinter is very important for charging in the blast furnace, and this can be controlled by proper sintering. SE (2b)

New Method for the Production of Oxygen to Enrich the Blast Furnace Blast (Neue Verfahren zur Gewinnung von Sauerstoff zur Anreicherung des Hochofenwindes). E. KARWAT. *Stahl und Eisen*, Vol. 55, Aug. 8, 1935, pages 860-863. Describes improvement in the Linde process for obtaining O_2 from liquid air, consisting of a new type liquefier and O_2-N_2 separator. SE (2b)

Further Determinations of the External Heat Loss of Blast Furnaces. D. F. MARSHALL. *Iron & Coal Trades Review*, Vol. 130, May 3, 1935, pages 761-764; May 10, 1935, page 813; *Engineer*, Vol. 159, May 10, 1935, pages 483-484; *Engineering*, Vol. 139, May 10, 1935, pages 503-505; May 17, 1935, pages 524-525; *Industrial Heating*, Vol. 2, June 1935, pages 313-314. See *Metals & Alloys*, Vol. 6, Oct. 1935, page MA 388R/5. MS + Ha + LFM (2b)

Observations and Theory on Slack Wind Blast Furnace Operation. FRANCIS M. RICH. *Iron Age*, Vol. 135, Feb. 28, 1935, pages 30-32; *Steel*, Vol. 96, Mar. 4, 1935, pages 69-70, 73; Mar. 11, 1935, page 52. See *Metals & Alloys*, Vol. 6, Sept. 1935, page MA 349R/9. VSP + MS (2b)

Proposed Method of Making Cast Steel in the Blast Furnace (Vorschlag zur Rohstahlerzeugung im Hochofen und zur Verhüttung saurer Erze nach einem Verbundverfahren). M. FRÄNKL. *Stahl und Eisen*, Vol. 55, July 25, 1935, pages 805-809. A method is proposed for making low-C low-Si cast-steel in the blast furnace. The furnace is charged first with lump ore, then in the middle portion with coke, limestone, and fine ore. The lump ore may be replaced by briquets of ore, C, and limestone. The reducing gases formed by the combustion of the coke ore to be supplemented by blast furnace gas and the furnace run so that the reduced metal does not come into contact with coke and pick up too much C. The temperature is to be raised by enriching the blast to 33% O_2. The tapped metal is to be further refined with FeO in a rotary furnace. SE (2b)

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3. MELTING, REFINING AND CASTING

1 —

Casting Under High Pressure (La Fonderie sous Pression Elevée). Ladislav Jenicek. *Bulletin de l'Association Technique de Fonderie,* Vol. 9, June 1935, pages 190-197. Paper presented by Czechoslovakian representative before the A.T.F., Apr. 1935. See *Metals & Alloys,* Vol. 6, Sept. 1935, page MA 350R/3. WHS (3)

2 —

Foundry Sands. T. R. Stanley. *Transactions, Canadian Institute of Mining & Metallurgy, 1935 (in Canadian Mining & Metallurgical Bulletin* No. 281, Sept.) pages 391-396. The properties of a good molding sand, the chemical and mineralogical constituents of sands and the effect of each, and cementing materials for foundry sands are discussed. AHE (3)

3 —

Modern Equipment Used in Crucible Melting. Richard H. Stone. *Transactions American Foundrymen's Association,* Vol. 6, Feb. 1935, pages 265-277. Crucible melting recently has received an impetus due to the adoption of fuels not generally used previously, to better refractories, greater crucible life and new furnace design. Cost analysis of various fuels used in crucible melting are given. Some new types of installation are described. See also *Metals & Alloys,* Vol. 6, July 1935, page MA 284R/6. CEJ (3)

4 —

Strickle Moulding of Large Castings. H. Fabre & H. Dubois. *Foundry Trade Journal,* Vol. 53, July 11, 1935, pages 34-36; July 18, 1935, pages 51-54. French exchange paper read before the Annual conference of the Institute of British Foundrymen at Sheffield 1935. Strickle molding may be effected either in sand or in loam. The patternmaking equipment is very simple and comprises the following: a. The "matrix board," serving to obtain the false pattern in sand which permits the ramming of the top portion and b. the "claw" for hollowing out the lateral and lower shapes of the casting. In loam molding the 2 portions of the mold are formed independently of each other, for which 2 distinct boards are required: one for the upper portion, the other for the body and the bottom portion. Equipment, plain castings of circular section, horizontal strickle molding (rolling-mill roll, weight 2300 kg), eccentric strickle molding (grooved flywheel in two half-parts, weight 4000 kg), rectilineal or curvilineal strickling (molding of a pipe-bend, weight 1000 kg), castings molded partly by means of skeleton patterns and partly by strickling (filter shell, weight 5000 kg) etc. are discussed by the authors. AIK (3)

5 —

3a. Non-Ferrous

G. L. CRAIG, SECTION EDITOR

6 —

The Use of Charcoal in the Nonferrous Foundry. R. J. Keeley. *Transactions American Foundrymen's Association,* Vol. 6, Feb. 1935, pages 184-190; discussion, *Industria Meccanica,* Vol. 17, July 1935, pages 619-621. Although charcoal has many advantages, it also has disadvantages and whether or not it should be used and where, depends on the type of melting unit and the furnace atmosphere. Charcoal can perform 3 definite and distinct functions, namely, prevent oxidation of the metal; deoxidize the metal; or gas the metal. Various practices for different types of furnaces are given and recommended. CEJ + Ha (3a)

7 —

Metal Losses in Melting Brass and Other Copper Alloys. Maurice Cook. *Journal Institute of Metals,* Vol. 57, June 1935, pages 249-264 (Advance Copy No. 703). A study was made of losses occurring when such alloys as gilding metals, brasses, and cupro-nickel are melted in crucibles in coke-fired pits. Data were obtained both from trial runs and from production runs extending over a long period. Total metal losses varied from 0.29 to 2.42%, depending on the alloy being made and on the shop. A study was also made of losses when melting in Ajax-Wyatt induction furnaces. The major loss was due to oxidation. Various fluxes and other addition agents were experimented with in attempting to reduce the oxidation loss. The method of melting finally adopted consisted of adding 2 lb. of charcoal after the heat was poured and then adding the next charge. When melting is complete and the heat is ready for pouring about ½ lb. of a mixture of salt and borax is added and stirred into the charcoal and dross, after which the dross is skimmed away. When melting α brass and using this practice the loss does not generally exceed 1%. JLG (3a)

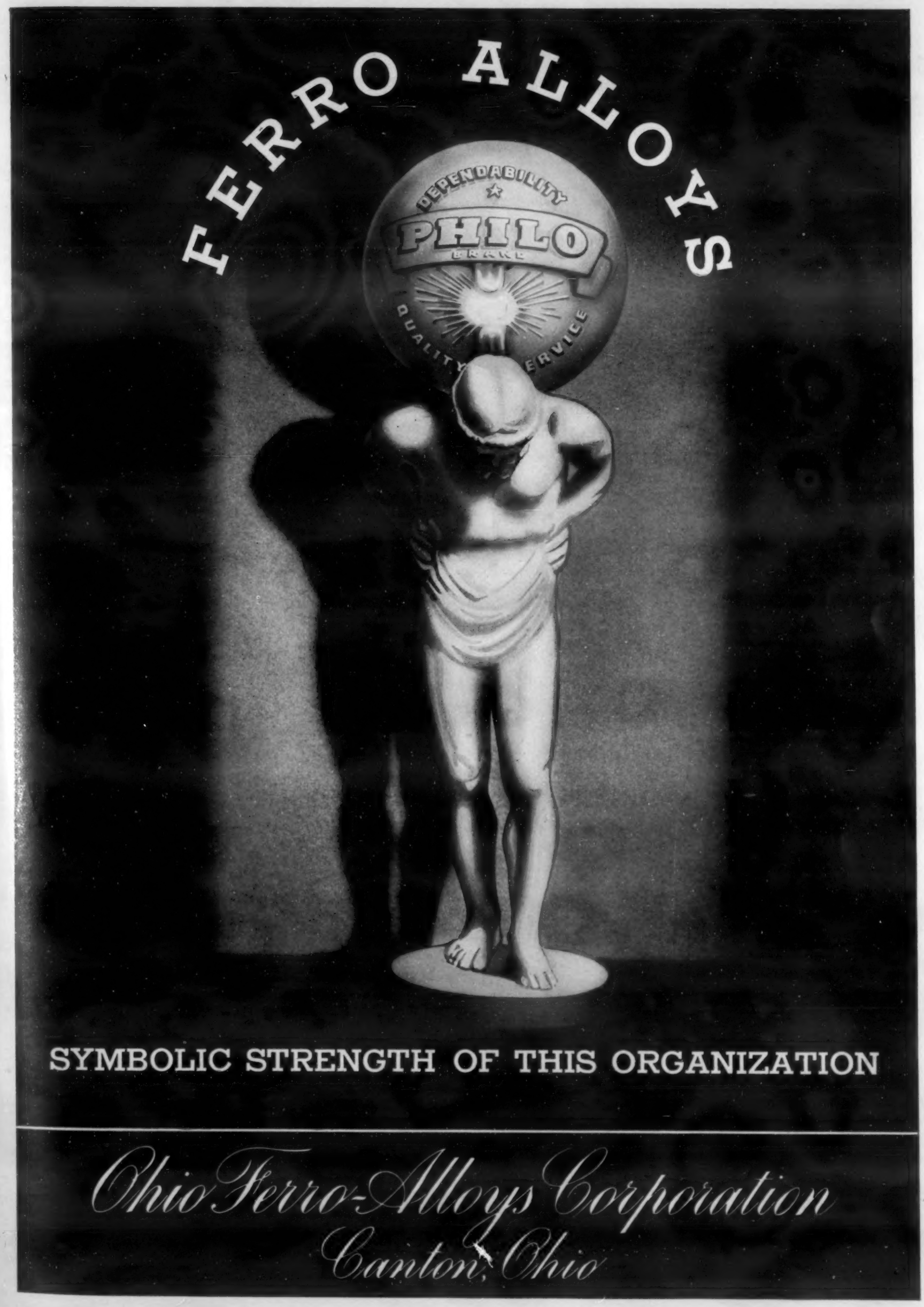
8 —

Progress of the Aluminum Foundry (Les Progrès de la Fonderie d'Aluminium). Dumas. *Bulletin de l'Association Technique de Fonderie,* Vol. 9, No. 3, Mar. 1935, pages 86-91. Paper presented before the A. T. F., Jan. 26, 1935. Grain size of Al-Si alloys may be refined by the addition of alkali metals such as Na or K. Gases, especially H, may be removed from Al alloys by the addition of $MnCl_2$ or double fluorides of Ti and K. Corrosion resistant alloys of Al may contain Mg and Mn, or Mg and Cr, Mg, Mn, and Sb. Boric acid is added to the molding sand to prevent oxidation of Mg rich alloys of Al. A long interval of solidification necessitates special attention to gates and risers. WHS (3a)

9 —

Deoxidation and Degasification of Red Brass and Bronze. O. W. Ellis, J. W. Bolton & E. R. Darby. *Transactions American Foundrymen's Association,* Vol. 6, Feb. 1935, pages 160-172. Report prepared by the committee of the A.F.A. Nonferrous Division. Troubles of foundrymen would be largely eliminated in the nonferrous field if the metals did not react with the oxygen of the air to form oxides and did not dissolve certain of the gases under which they stand in the molten state. Effects of O, S and H are discussed. Fusion of alloys containing reactive oxides in a reducing atmosphere, or in one containing S in general results in incipient shrinkage and oxidized metal, i.e. metal characterized by fractures dark-red to chocolate in hue. By carefully choosing the ingredients of the charge, by limiting the formation of oxides during the first stages of melting, and by the use of suitable fluxes, the proportions of reactive oxides in a given melt can be reasonably regulated. 70 references. CEJ (3a)

10 —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Deoxidation and Degasification of Non-ferrous Casting Alloys. C. H. Lorig. *Transactions American Foundrymen's Association*, Vol. 6, Feb. 1935, pages 152-159; *Foundry Trade Journal*, Vol. 52, Mar. 7, 1935, pages 173-174. Most of the difficulties ascribed to non-metallic elements can be traced to moisture. Moisture reacts with a large number of molten metals to form an oxide, that is either dissolved, suspended, or slagged off, and H, part or all of which may be absorbed by the metals. The ability of a metal to dissolve non-metallic elements will depend on the ability of that metal to dissociate them or to form soluble compounds with them. In practice it is becoming more generally accepted that atmospheres either neutral or slightly oxidizing to the metal or alloy in question are in the long run most satisfactory for melting. Schemes for eliminating the deleterious effects of non-metallic elements in non-ferrous castings are mostly dependent on such fundamental conceptions as the change in solubility of the non-metallic elements in metals with temperature, concentration, and pressure, and furthermore, upon the change in solubility on the addition of other impurities. CEJ + AIK (3a)

Deoxidation and Degasification of Yellow Brass. L. A. Ward. *Transactions American Foundrymen's Association*, Vol. 6, Feb. 1935, pages 173-183; *Foundry Trade Journal*, Vol. 52, Jan. 31, 1935, page 89; Feb. 14, 1935, page 126. In discussing deoxidation, the author reviews the effects of various elements present in yellow brass, such as Cu, Zn, Sn, Pb. The effects are also outlined of such deoxidizers as Al, Si, Mn, P, Li, Ca with regard to the formation of oxides that may be present in the melt. The conclusion is reached that various deoxidizers are unnecessary and merely confer fluidity on the melt. Under degasification, the author gives 3 sources of gases in castings, namely, (1) gas retained in the metal going into the charge, (2) gas picked up during melting, (3) gas entrapped in the molten metal in the mold. It is concluded that probably the best method of degasification is pouring the metal at as low a temperature as possible. A table accompanies the paper which shows the results of various deoxidizers and varying pouring temperatures on the physical properties of the castings. CEJ + AIK (3a)

Manganese Bronze and Brass. Wesley Lambert. *Metal Industry*, London, Vol. 45, Dec. 14, 1934, pages 567-572. See *Metals & Alloys*, Vol. 6, May 1935, page MA 179R/8. HBG (3a)

Sand Problems in a Brass Foundry. F. Howitt. *Foundry Trade Journal*, Vol. 53, July 4, 1935, pages 9-13. Paper read before the Annual Conference of the Institute of British Foundrymen. Moisture control, variation in grain size, recording grain size, overcoming core troubles, fully compressed sands, selection of a binder, dextrin oil binders, determination of metal pressure, blowing control etc. are discussed by the author. When molten metal comes into contact with core, gas is evolved as a result of the decomposition of the bond. This gas, together with the air already present, is expanded to two or three times its normal volume by the rise in temperature. If the pressure of the gas becomes equal to or greater than the pressure of the metal around the core, then metal will be displaced by gas and a "blow" will appear. The determining factor is the pressure of the metal and this may be taken as the product of the height of metal in the runner and the density. Different methods of blowing control are considered. The paper is illustrated by number of diagrams. AIK (3a)

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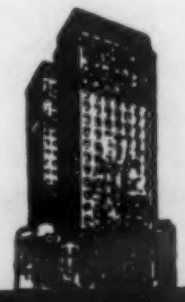

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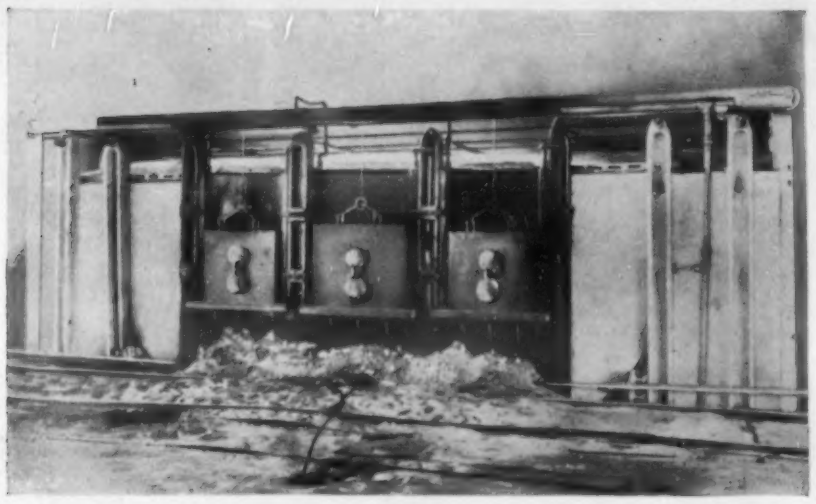

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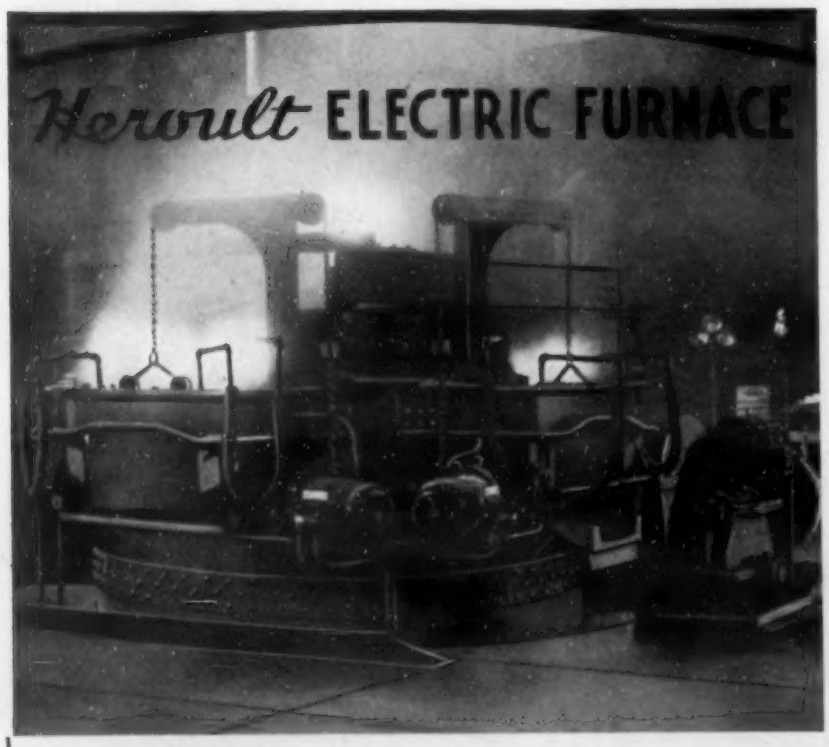

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The Avonmouth Works of the National Smelting Co., Ltd. *Metal Industry*, London, Vol. 46, Feb. 1, 1935, pages 141-143. An abstract of a paper read by D. S. Burwood before the Midland Metallurgical Societies Jan. 15. The major operations of the company are the production of Zn and H_2SO_4 as a by-product. The 1 raw materials are Zn blende flotation concentrates from New South Wales and Newfoundland which assay approx. 50-53% Zn and 30-32% S with small amounts of Pb, Ca, Fe and gangue. Radical changes in the process of elimination of S, the first stage in the metallurgy of Zn, have been made in the last decade and desulphurization is now conducted by direct sintering. For successful operation correct proportions of finished sinter and raw concentrate must be used. The resulting mixture with 5.5% S is easily desulphurized to 0.3% and lower percentages 2 have been obtained. The SO_2-bearing gases are utilized in the manufacture of H_2SO_4 by the contact process. This section of the work is divided into three stages; (1) purification of gases, (2) oxidation or conversion of SO_2 to SO_3, (3) absorption of SO_3. The furnaces used for distillation are of the Rhenish type, contain 384 retorts in 4 tiers, placed on either side of the furnace. The furnaces, divided into 4 sections each of which has independent controls for air and gas, are heated by producer gas using a regenerative system. The furnaces are charged by hand with crushed sinter and anthracite duff. The operating temperature ranges from 1000° C. at the beginning of the cycle to a max. of approx. 1400° C. when distillation is complete. Each furnace is capable of producing 12½ tons/day with a 91-92% recovery of the Zn charged. Metal produced in the latter part of each distillation requires further refining which is carried on in a coal-fired reverberatory furnace with a capacity of 20 tons. This metal then assays 0.98-1.15% Pb. 3 Additional equipment, recently installed, makes possible the production of Zn 99.8-99.9% pure, which upon refining is over 99.9% Zn. HBG (3a)

Propeller Manufacture. Wm. Ashcroft. *Metallurgia*, Vol. 12, Aug. 1935, pages 107-110. Describes manufacture of large propellers from Cu-base alloys. JLG (3a)

Midland Metallurgical Societies Open Discussion on the Production of Brass Ingots. *Metal Industry*, London, Vol. 45, Nov. 2, 1934, pages 411-412; Nov. 9, 1934, pages 444-445, 451. First meeting of Birmingham Local Section of Institute of Metals held Oct. 25, 1934 was in the form of an open discussion. G. L. Bailey's 4 discussion was based on (1) The particular qualities desired in ingots and (2) how best to secure these qualities in practice. Under (1) were considered (a) smoothness of surface, (b) internal soundness and (c) fine-grained equiaxial crystal structure. Under (2) were included suggested means of obtaining (a) smoothness of surface, (b) the avoidance of oxidation during pouring, (c) soundness and (d) elimination of shrinkage. He indicated the advantages and disadvantages of the Durville Process, which method he recommended for use. Genders discussed columnar structure as a possible source of cracking during the breaking down of ingots. He also pointed out the false economy of the use of cracked molds and indicated that with more scientific technique in casting Cu molds should be more generally used. Other 5 factors considered were thickness of an ingot, vibration of the mold, pouring temperature, and heat flow in molds. HBG (3a)

3b. Ferrous

C. H. HERTY, SECTION EDITOR

Colloidal Physical-chemical Methods of Separation of Slag Inclusions Eliminated from Steel, from Carbides. S. M. Gutman, P. A. Rebinder, M. D. Sul'vas, 6 M. E. Lipec & M. M. Rimskaa. *Dokladui akademii nauk SSSR*, New Series, Vol. 3, Feb. 11, 1935, pages 308-311. In Russian. German summary on page 312. Detailed descriptions and discussion of a method for separation of slag inclusions eliminated from steel with 0.3-1.0% C, from C (graphite) originating upon decomposition of the carbides with a neutral $CuCl_2.2NH_4Cl$ solution, by a selective dispersion and peptization of graphite in aqueous alkaline solutions of tannine or Na-alizarin sulphonate. The method has the advantage of leaving the slag inclusions entirely unaffected so that their crystal structure and exact chemical composition can be conveniently determined. ORS (3b)

Behavior of Gray Iron Castings Between 650° and 800° and the Influence of Silicon (Comportamiento de la fundicion gris entre 650° y 800° e influencia del silicio). E. Jimeno & A. Modolell. *Anales de la Sociedad Española de Fisica y Quimica*, Vol. 33, Mar. 1935, pages 279-296. The influence of 7 heat treatment between 650° and 800° C. on gray iron castings with different silicon contents (1.04, 1.52, 1.94, 2.59%) was studied. Twelve diagrams show the changes of hardness with the different temperatures at the different times. The changes are followed on 60 micrographs. In all annealings it was observed that the decomposition of Fe_3C is stronger the longer the annealing and the higher the temperature. In all cases the pearlite tends to acquire a globular form. A close 8 relation was found between combined carbon, hardness and microstructure, the Si having no influence on the hardness because of the small amounts used. FRM (3b)

Molding of a Cylinder Cover without Use of Core Support (Herstellung eines Zylinderdeckels ohne Verwendung von Kernstützen). F. Vogelsang. *Giesserei*, Vol. 22, Aug. 2, 1935, page 387. The method has the purpose of avoiding use of core supports to obtain a dense casting. Ha (3b)

Some Practical Data on Refining Ferromanganese Containing Carbon. U. D. Nikonoff. *Metallurg*, No. 5, May 1934, pages 70-82. In Russian. The 9 method of obtaining low C ferromanganese from high C ferromanganese is described. Ferromanganese containing 7% C and ferrosilicon are mixed in proportion 2 : 1 and melted down in electric arc furnace. Then the refining is done for removing Si. The refining slag is removed several times and is built with a Mn ore and lime. The finished ferromanganese contains 0.6-1.0% C; 60-70% Mn; 1.5-2.0% Si; 0.1-0.3% P. VK (3b)

Influence of MgO Addition to Calcium Slags on Their Leaching Characteristics by Soda. G. K. Magarshak. *Legkie Metalli*, May 1935, pages 22-27. In Russian. CaO, Al_2O_3, SiO_2 and MgO which were almost chemically pure were fused in a C tube 10 at 1500°-1700° C. The fusions were leached for one hour at 75° and 95° C. in soda solution. Figures obtained on 33 melts are given indicating that MgO addition to $CaO-Al_2O_3$ slags leads to formation of Mg spinel and melilite insoluble in Na_2CO_3 which leads to considerable Al_2O_3 losses in leaching and to the formation of silica compounds insoluble in soda leading to solutions with low SiO_2 content. (3b) These results were checked petrographically.

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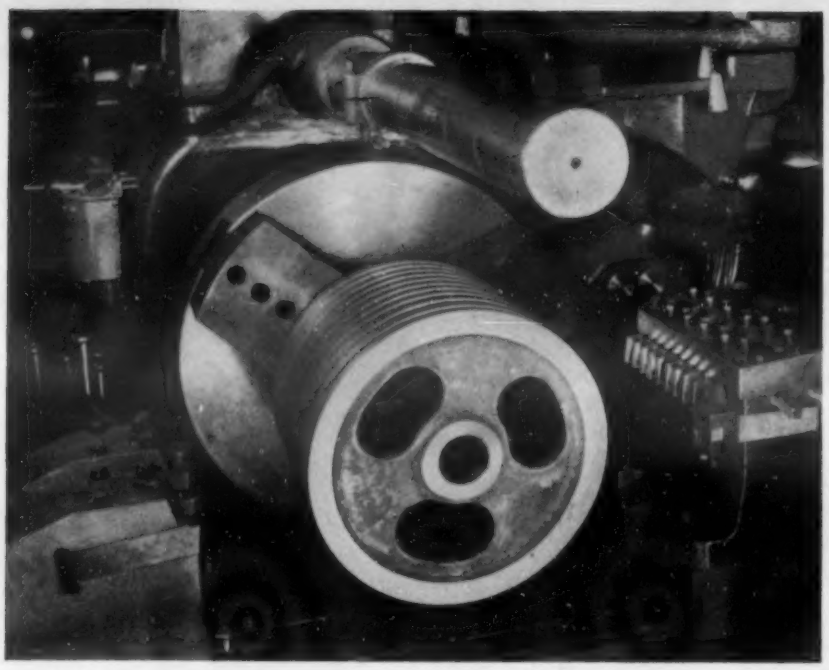

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4. WORKING

1 **New American Sheet Mill.** *Metal Industry,* London, Vol. 45, Nov. 2, 1934, pages 421-422. A description of the new plant of the Flemin Lead Co., Inc. of Long Island City, N. Y. which began operation July 1, 1934. The melting equipment is an oil-fired pot of 15,000 lb. capacity. This is supported on the brick work of the combustion chamber around which is an insulating jacket of sil-o-cel brick. The rolling mill and accessory equipment are described. HBG (4)

4a. Rolling

RICHARD RIMBACH, SECTION EDITOR

2 **Installation and Care of Roller Bearings in Rolling Mills (Ausführung und Bewährung von Rollenlagern, Bauart Schöpf, im Walzwerksbau).** A. SCHÖPF. *Stahl und Eisen,* Vol. 55, June 13, 1935, pages 648-653. Design of roller bearings for strip, shapes, and wire rod are described. SE (4a)

3 **Installation and Calculation of Roller Bearings in Rolling Mills (Ausführung und Berechnung von Rollenlagern im Walzwerksbau, Bauart Kugelfischer).** H. SCHULZ. *Stahl und Eisen,* Vol. 55, June 6, 1935, pages 616-623. Cylindrical and conical roller bearings, especially for heavily loaded two-high mills are described, with details of roll design and lubrication. SE (4a)

4b. Forging & Extruding

A. W. DEMMLER, SECTION EDITOR

4 **The Manufacture and Testing of Steel Forgings.** W. H. HATFIELD. *Transactions Institute of Marine Engineers,* Vol. 47, June 19, 1935, pages 137-140; Discussion pages 140-143. Lecture to the Junior Section of the Institute of Marine Engineers, Mar. 1935, discusses killed, rimmed, semi-killed and balanced steel ingots, soaking and forging of steel ingots. Typical microstructures are shown. The analyses and important physical properties of 18 forging steels are tabulated. Wlf (4b)

5 **Lead Extrusion.** *Electrician,* Vol. 115, Aug. 2, 1935, page 148. Machine for the continuous extrusion of pipe to any length is described. Uniformity of the output and the elimination of flaws such as pin-holes, dross, splits, recipient seams and other imperfections are featured. Plain Pb and other common alloys such as Pb-Sn and Pb-Sb can be used. CBI (4b)

6 **Manufacture of Steel Forgings.** T. M. SERVICE. *Metal Treatment,* Vol. 1, Summer 1935, pages 76-81; *Iron & Coal Trades Review,* Vol. 131, Sept. 6, 1935, pages 347-349. For high-class forgings, ingots with minimum segregation, as free as possible from non-metallic inclusions and free from "corner ghosts" (carefully cooled) are necessary. In reheating, adequate time must be allowed. Diagrams are given showing the rate of temperature rise in the center of ingots from 20" to 60" in diam. The best rate of heating in hours is given by Bailey as $1/120$ of (diam. in inches)^2. The methods used in forging an intermediate shaft, connecting rod; crank webs; six-throw crankshaft; boiler drum; etc. are illustrated by sketches. JCC + Ha (4b)

4c. Cold Working, including Shearing, Punching, Drawing & Stamping

7 **Note on the Use of Back Pull in Wire Drawing.** P. M. MUELLER. *Wire & Wire Products,* Vol. 10, Sept. 1935, pages 419-426. The practical application of back pull to wire drawing is discussed; its effect is to reduce the pressure with which the metal may be crushed to a new size, thereby lowering parasitic friction and improving the inherently low die efficiency. Proper determination of back pull may result in a power saving of 25% and will lead to longer life of die and reduction of maintenance costs. A few examples from practice are given. Ha (4c)

4d. Machining

H. W. GRAHAM, SECTION EDITOR

8 **Machineability of German and American Structural Steels (Zerspanbarkeit deutscher und amerikanischer Baustähle).** A. WALLICHS. *Stahl und Eisen,* Vol. 55, May 30, 1935, pages 581-585. A series of German and American alloy carburizing and oil quenching steels were tested for machineability in roughing cuts. The curves for the life of the tools vs. cutting speed were very similar for the German and American steels. There was a uniform relationship between the Brinell hardness and the cutting speed at which the tool failed in an hour. Only 2 of the steels, one an American SAE 4615 and one a German ECN steel (.13% C, 3.6% Ni, .72% Cr) showed better than average machineability. The Brinell hardness may be considered as the simplest criterion of machineability for structural steels. SE (4d)

9 **Factors which Influence Car Wheel Turning.** DAVID ROBINSON. *Railway Mechanical Engineer,* Vol. 109, Sept. 1935, pages 378-381. Economical turning of modern, hard-rimmed car wheels is discussed; toughness and hardness of the wheel thread, depth of cut, amount of feed and cutting speed as influenced by material of the tool are described and practical data from experience given in curves. Only the best Co steels, properly heat treated and ground to correct shape are considered to give satisfactory results. Ha (4d)

10

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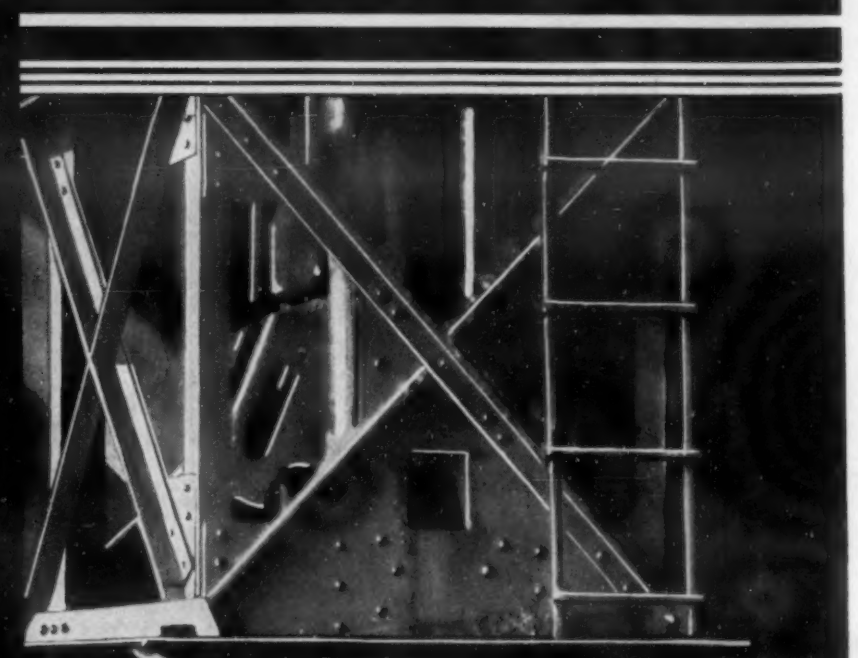

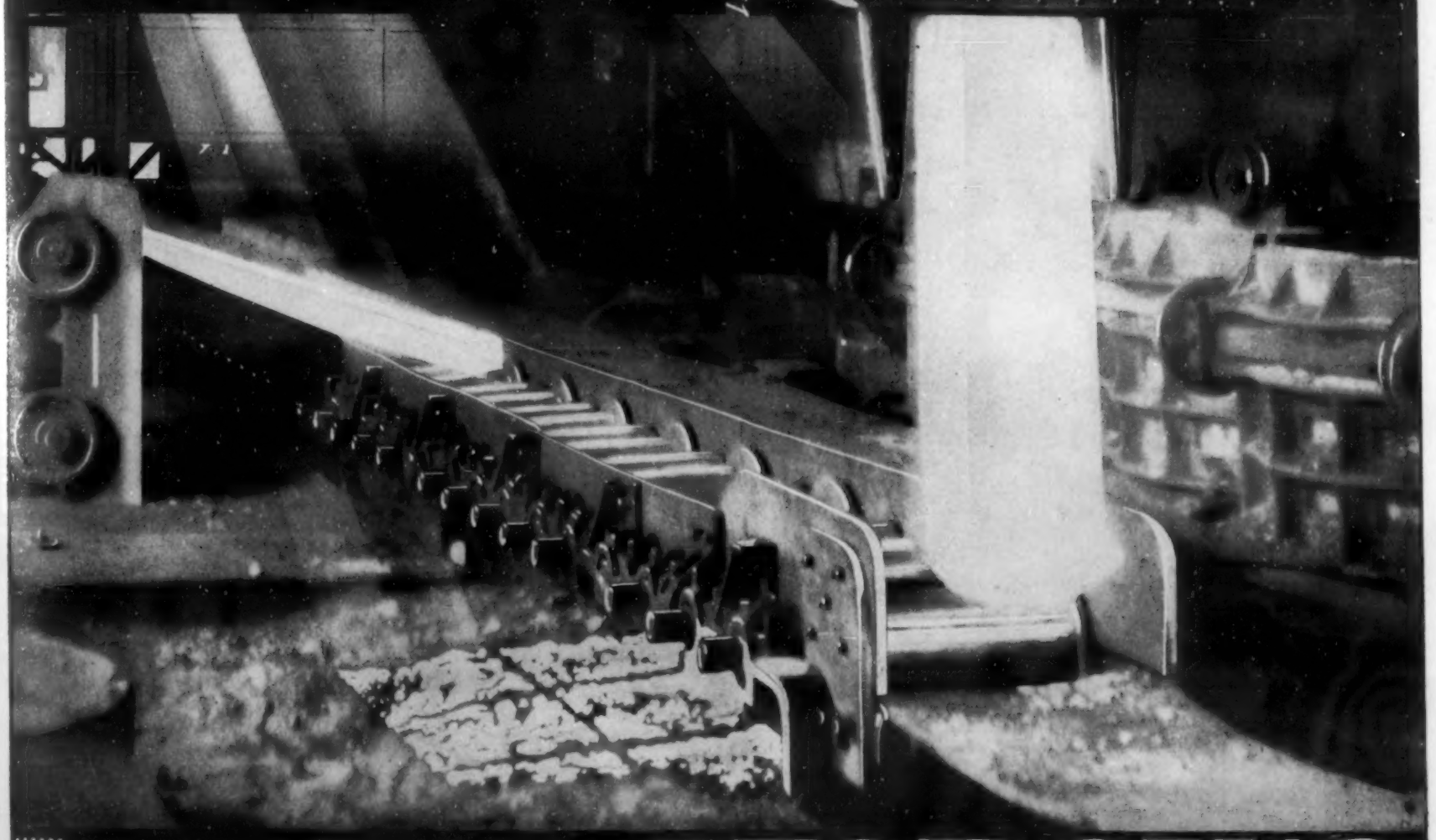

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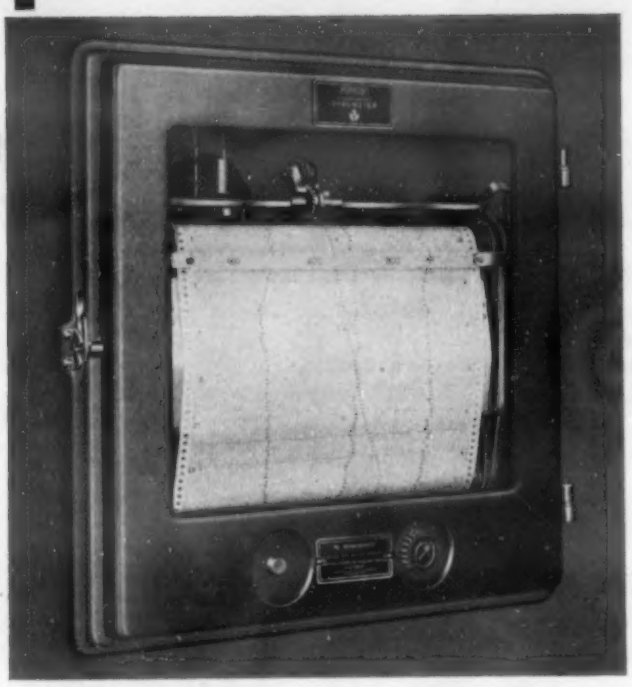

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5. HEAT TREATMENT

O. E. HARDER, SECTION EDITOR

1

Deformation Accompanying Heat Treatment of Cold Worked Metals (Sur les Déformations Accompagnant les Traitements Thermiques des Métaux Écrouis). MAURICE BONZEL. *Comptes Rendus*, Vol. 201, Aug. 5, 1935, pages 394-396. Alloys studied consisted of pure Cu, pure Ni, solid solutions of Fe-Cr, austenite of Cr-Ni-Fe and Fe-Mn and 2 phase alloys of Al-Cu and C steels. Cylindrical samples were cold worked by torsional stress, hung vertically in a furnace and observations made of deformation during thermal cycles of heating and cooling. Graphs show the effect of varying the initial torsion on the resulting deformation occurring on heating which is characteristic for each alloy studied. FHC (5)

2

5a. Annealing

3

Recrystallization of Pure Aluminum (Sur la recristallisation de l'aluminium pur). JEAN CALVET, JEAN-J. TRILLAT & MILOSLAV PAIC. *Comptes Rendus*, Vol. 201, Aug. 12, 1935, pages 426-428; *Journal du Four Electrique*, Vol. 44, Aug. 1935, page 282. Authors continue their earlier work (*Comptes Rendus*, Vol. 200, Mar. 18, 1935, pages 1037-1039; *Metals & Alloys*, Vol. 6, July 1935, page MA 280) by X-ray studies on recrystallization of Al in relation to its purity. Exceptionally pure Al, 99.9986%, was used containing 0.0002% Fe, 0.0009% Si and 0.0003% Cu. JDG + FHC (5a)

The Bright Annealing of Non-Ferrous Metals. W. WIRT YOUNG. *Gas Age-Record*, Vol. 75, Apr. 27, 1935, pages 409-411, 414. Description of production of partially combusted gas for bright annealing of Cu, Ni, and non-Zn-bearing non-ferrous metals and alloys. VVK (5a)

4

5b. Hardening, Quenching & Drawing

New Method of Hardening High-Speed Steel Hack-Saw Blades. J. TRICKETT. *Metal Treatment*, Vol. 1, Summer 1935, pages 100-101. Description of apparatus for holding hack-saw blades under tension and heating for air-hardening by passage of electric current. Temperature is indicated by expansion of blade. Distortion of blades and overheating of teeth are avoided, and ends, held by clamps, remain soft. Separate annealing operation for ends is thus avoided. JCC (5b)

5

Heat Treatment in Magnetic Fields. G. A. KELSALL. *Bell Laboratories Record*, Vol. 14, Sept. 1935, pages 26-28. Magnetic properties of certain materials such as "perminvars" and "permalloys" were found to be considerably superior if they were subject to magnetic fields during heat treatment. Maximum permeabilities of over 140,000 could be obtained in this manner. A few examples of applying this method to magnet steels are described. Ha (5b)

6

Heat Treatment of Metals Used in Aircraft. HORACE C. KNERR. *Aero Digest*, Vol. 27, July 1935, pages 22-24. Strength of forgings, bolts and engine parts is required to be only 150,000 lbs./in.^{2} thus permitting heat treatment in semi-finished condition and final machining is undertaken with minimum trouble due to surface or distortion. A special furnace is required to heat treat aircraft parts and description and photos are given of the furnace. The parts are suspended in the furnace vertically and the quenching tank placed so as to be directly under the door. The parts are quenched vertically thus eliminating distortion due to heat treatment and quench. The ductility is more critical than the tensile value and it is usual to heat treat to 10-15% higher tensile provided the minimum elongation value can be met. The Army and Navy specification will accept a lower elongation for thinner material because after identical heat treatment thin samples show very much smaller elongation values than thick samples of the same tensile strength. WB (5b)

7

Quenching Wheel Tires in Oil. M. ARONOVICH & A. BUTKOV. *Stal*, Vol. 4, Sept.-Oct. 1934. pages 45-51. In Russian. Wheel tires immediately after rolling were either given a limited water quench (40-70 sec.) and drawn at 540°-580° C. or oil quenched and drawn. The macro and microstructure of the oil quenched tires were slightly though not significantly more homogeneous than of those water quenched. The Brinell hardness at the edge of the tires was 7 units greater than in the center for water quenched tires and 1½ units greater for oil quenched tires. Contrary to expectation the oil quenched tires did not have better mechanical properties; in fact impact resistance was less than for the water quenched tires. HWR (5b)

8

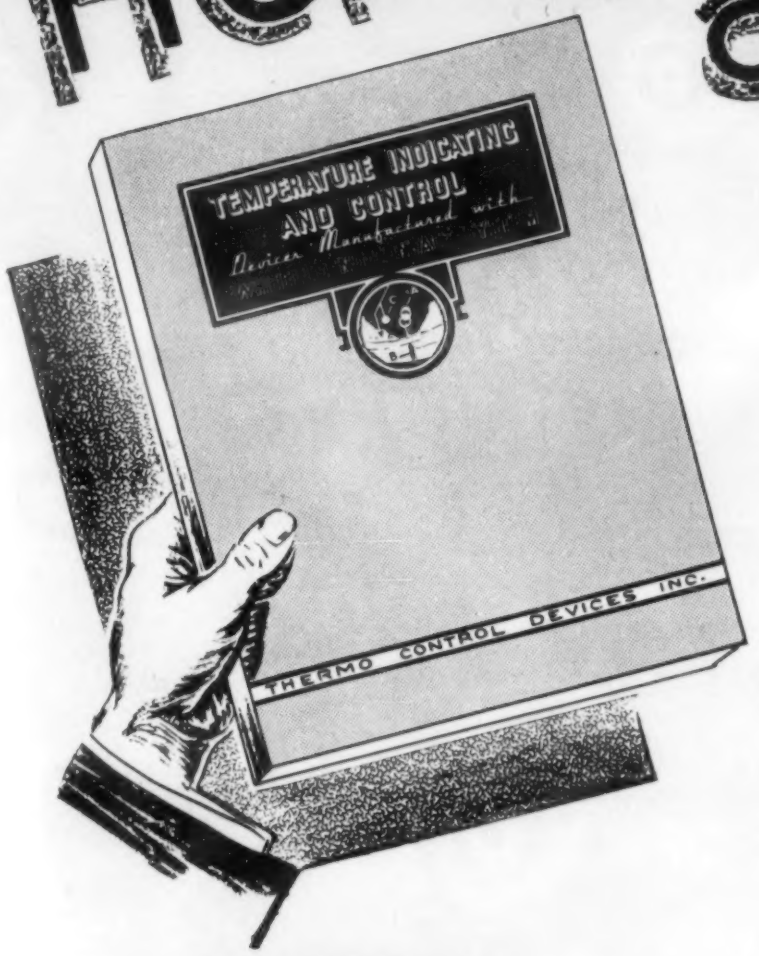
5e. Carburizing

9

The Different Methods of Case Hardening in the Electric Furnace. FR. KNOOPS. *Elektrowärme*, Vol. 5, Sept. 1935, pages 226-229. Four processes of case hardening are distinguished; (1) with carbon powder, (2) with "durapid," a hardening paste, (3) in the salt bath, (4) in gases (nitriding). All methods give equally good results, their application depends on material to be hardened, its shape, its delicacy against deformation and general operating conditions in the plant. The paste method is particularly advantageous as it requires less space and less energy as the masses to be heated are less than in either the first or third method; a temperature of 900° C. with the exclusion of air is required. Salt baths permit obtaining a hardened depth of 2 mm. in 6 hrs. at temperatures of 300°-400° C. Nitriding requires about 550° C. in an ammonia atm., higher temperatures cause brittle marginal layers. The principal difference between nitriding and other case hardening methods is that no intermediate treatment, as quenching and annealing is required. The piece obtained is not hardenable but naturally hard. The hard layer is about 0.1 mm. after 15 hrs. and 0.4 mm. after 50 hrs. The advantages of electric furnaces for these methods are discussed and operating data and temperature control briefly described. Ha (5e)

10

Here's a Book which



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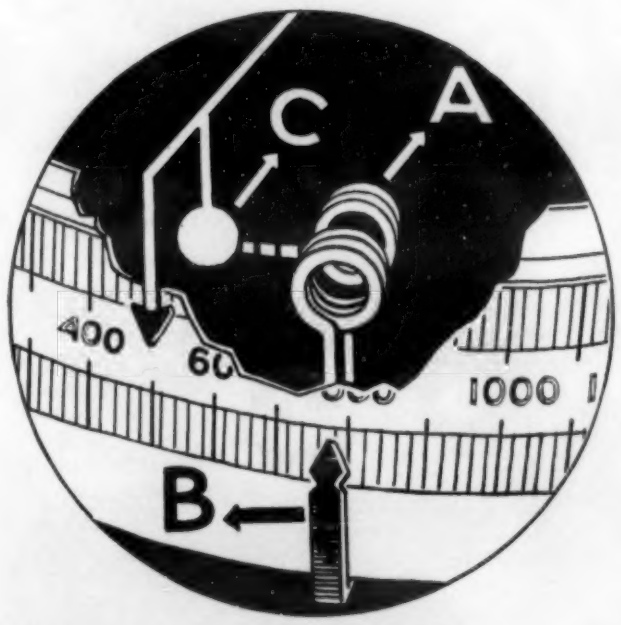

How the Wheelco System Operates

Referring to above sketch: Between the coils "A" (which are attached to and move with temperature limit set pointer "B") a current flows on a given wave length. The heat indicator carries the tiny flag "C" which, when it enters into the coil "A," changes the wave length on the same principle as turning the dials of a radio set. As a result a new wave length is set up, causing the rise in current of a vacuum tube, which in turn starts an electrical relay to function.

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6. FURNACES, REFRACTORIES AND FUELS

M. H. MAWHINNEY, SECTION EDITOR

Electrical Installation for Bright Annealing (Une installation électrique de recuit à blanc). ALEXANDRE SEVASTOPOULO. *Journal du Four Electrique*, Vol. 44, Aug. 1935, pages 289-292. Mechanical features and the results of operation of a Siemens-Pruefert installation for bright annealing of coils. The furnace is vertical and resistance heated. Its particular feature is axial heating which greatly improves the uniformity of the temperature throughout the heated mass by equalizing the action of the heating units located at the periphery. The furnace is used for heating only, cooling is effected in special cooling devices provided with water circulation. Coil container is placed in the furnace as a whole unit, heated as required and then removed to the coolers. JDG (6)

Soaking Pits for the Blooming Mill at Dzerjinski Plant. B. BURIANOV & J. KIESELHOF. *Domez*, No. 6, 1935, pages 58-69. In Russian. Mechanical features of the regenerator type soaking pits installation used at this plant and a critical comparison between it and the installations at Kuznetzk and Magnitogorsk plants. (6)

Radiation Electric Furnace at the Saint-Ouen Plant of Fenwick Company (Le four électrique à rayonnement à l'usine de Saint-Ouen de la société Fenwick). *Journal du Four Electrique*, Vol. 44, July 1935, pages 249-250. Heating unit of furnace which consists of a horizontal cylinder terminating with 2 truncated cones is a graphite rod supported on both ends. Electric current of high amperage and comparatively low voltage passes through it heating it to incandescence. The current is introduced only at one side (patented feature) which permits a special construction to eliminate eddy currents and other losses so that the efficiency is 98%. During charging the electrode is removed from the furnace. A 100 kg. furnace operating at the plant melts the charge of Ni-Cr stainless steel in 25 minutes starting with a cold furnace and operating at 1750° C. Diameter of the electrode is 4 cm., length 1.2 meter. It is run at 32-40 volts, 2500-3000 amperes consuming 2.5-3.0 kg. of electrodes and 700 kw. hr./ton. Particular advantages of the installation are simplicity of electrical equipment, high efficiency, and lack of carburization of the bath. About a dozen of these furnaces are now in industrial use. JDG (6)

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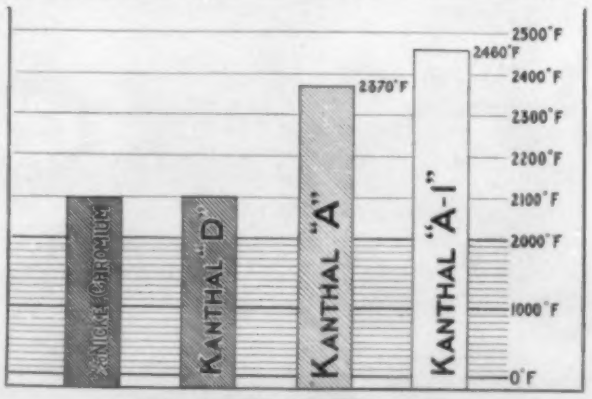

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Electric Melting Practice. A. G. Robiette. J. B. Lippincott Company, Philadelphia, 1935. Cloth, 6 x 9 inches, 324 pages. Price $7.50.

The author is chief metallurgist of Birmingham Electric Furnaces, Ltd. and naturally has a highly favorable point of view toward electric melting. At times this verges upon propaganda and some electric melting applications are described in terms that might lead the reader to think that their economic status is more fully settled than is actually the case. However, if one takes it for granted that electric melting is the proper method—and in a large majority of the cases dealt with, this is so—very useful and practical information on the operation of the electric melting processes will be gained from the book.

The design of furnaces is discussed only insofar as is essential to an understanding of their operation, the author sticks to his subject. Only those furnaces of present-day commercial utility are dealt with in any detail, and in reference to melting processes the tense used in the description is usually quite accurate, methods not now in use taking the past tense and but brief description.

The book is not only up-to-date, but, for an English book, contains an astonishing amount of information on American practice. Several important German investigations are summarized in helpful fashion.

Processes for electric melting of wrought steel, cast steel, cast iron and the non-ferrous alloys are described concisely, but usually quite adequately, with many details that can only have been gained from considerable operating experience. Methods of lining furnaces receive due atttention. The metallurgy of the processes described is well explained. In several cases where the classical explanation of a phenomenon has been shown to be incorrect or at least doubtful, Robiette discusses the matter with good discrimination.

The book is clearly written, and will be understood by the average high-grade furnace operator, to whom, as well as to the metallurgist, it will be of practical assistance. It's a worth-while volume. H. W. Gillett (6) -B-

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Construction and Use of Large Induction Furnaces (Bau und Betrieb grosser kernloser Induktionsöfen). F. Bardenheuer. *Stahl und Eisen,* Vol. 55, Aug. 1, 1935, pages 821-825. Gives layout and performance of a 4000 kg. induction furnace and discusses advantages and disadvantages of induction furnace melting for various types of steel. SE (6)

Laboratory Electric Furnace for Very High Temperatures (Four électrique de laboratoire pour les températures tres éleveés). Henri George. *Journal du Four Electrique,* Vol. 44, Aug. 1935, pages 285-289. Graphite coil is inserted within a thin walled graphite cylinder with which it is electrically connected at one end and serves as the resistor for the furnace. Current is admitted both to the coil and to the cylinder on the opposite sides through carbon contact blocks cooled with water. The unit is inclosed in a properly heat insulated steel housing rotating on trunnions. A refractory tube inserted in the coil serves as a crucible. The furnace can be easily operated at 2000°C. either under vacuum or pressure. JDG (6)

Design of Diffusion Gas Burners. V. F. Kopytov & V. K. Ivanov. *Domez,* No. 6, 1935, pages 72-75. In Russian. Theoretical considerations, and an example of burner of the diffusion type as applied to forging furnaces to prevent scaling. (6)

Reactivity of Carbonaceous Materials in Electrothermic Processes. M. S. Maximenko. *Domez,* No. 6, 1935, pages 44-47. In Russian. Reactivity of coke can be increased by adding K or Fe or decreased by Al_2O_3 and SiO_2 additions, as it was shown by the work of previous investigators the references to which are given. Most of it was done below 1600° C. In the present work the temperature range around 2000° C. was studied. Ash determination in coke packing of electrode graphitization furnace after the completion of a run showed a decrease of ash content from 12.74% on the outside to 0.41% near the center of the furnace. Analysis of the ash is not given but its volatilization is clearly shown. Experimental preparation of CaC_2 with coke containing 0.5% Fe and with pure coke showed a pronounced increase in carbide content. (6)

Construction and Use of Induction Furnaces for Steel Making (Ueber die Bauart und Anwendung des kernlosen Induktionsöfens im Elektrostahlbetrieb). F. Pölzguter. *Stahl und Eisen,* Vol. 55, July 18, 1935, pages 773-779. Several 4-ton and 1-ton induction furnaces which have proved practical and economical for steel melting are described. They are especially well adapted for alloy steel melting giving low alloy losses, and have also become indispensable for alloy steel castings. SE (6)

Waste-heat Boilers in Open-hearth Practice. Iron & Steel Industrial Research Council. *Iron & Steel Institute,* Special Report No. 10, Sept. 1935, 73 pages. Section A is a brief introduction in which it is stated that this is the second report of the Open Hearth Committee. Section B gives data on an accurately recorded trial of a waste-heat boiler. The trial was on a boiler using gases from a 50-ton basic open-hearth furnace. The furnace was operated with producer gas. The boiler was of the fire-tube type containing 350 tubes having an external diameter of 2". The length between the tube plates was 18 ft. and the diameter of the shell was 9 ft. The average gas inlet temperature was 850° F. and the outlet temperature 432° F. Steam at 141 lb./in.² and 475° F. was generated. In Section C the economics of waste-heat boilers are discussed. It is shown that appreciable, although not extravagant, savings can result from the use of waste-heat boilers in certain plants and that in other plants no saving will result from their use. Section D—**Notes on the Design, Installation and Operation of Waste-heat Boilers,** A. F. Webber, deals chiefly with design and the reasons for using boilers of a particular type. An example of calculating a boiler size and design is given. Section E is a historical summary of waste-heat boiler practice. The publications on waste-heat boilers are briefly reviewed. 27 references. JLG (6)

First Electric Arc Furnace in North Africa (Le premier four à arc industriel en Afrique du Nord). *Journal du Four Electrique,* Vol. 44, Aug. 1935, pages 283-284. A one ton steel melting furnace was installed at Oran. JDG (6)

Firing Furnaces with Pulverized Fuel. *Iron & Coal Trades Review,* Vol. 131, Sept. 13, 1935, page 385. Experiments with a 12 ton air furnace using high grade coal for pulverizing were successful so that all furnaces of the plant will be modified for this kind of fuel. Ha (6)

7. JOINING

7a. Soldering & Brazing

C. H. CHATFIELD, SECTION EDITOR

Penetration of Steel by Soft Solder. L. J. G. VAN EWIJK. *Engineering*, Vol. 139, Mar. 22, 1935, page 317; *Heat Treating & Forging*, Vol. 21, Mar. 1935, pages 121-124; *Steel*, Vol. 96, Apr. 8, 1935, page 24. Paper read before the Institute of Metals. See *Metals & Alloys*, Vol. 6, Sept. 1935, page MA 362R/3. VSP + MS (7a)

Special Atmospheres for Heat Treatment. C. L. WEST. *Heat Treating & Forging*, Vol. 21, July 1935, pages 334-337. Same as *Iron Age*, Vol. 135, May 16, 1935, pages 18-22, 86. See *Metals & Alloys*, Vol. 6, Oct. 1935, page MA 401L/8. MS (7a)

Brazing with Silver Solders. ROBERT H. LEACH. *Welding Journal*, N. Y., Vol. 13, Dec. 1934, pages 23-27; *Steel*, Vol. 95, Nov. 12, 1934, pages 29-32, 60. Tables and diagrams of composition, melting points, physical properties and conductivity of Ag solders. Table given of low melting point Ag alloys. Practically all ferrous and non-ferrous metals and alloys with melting point above 1300° F. can be soldered with Ag solder which is easily melted and flowed into the joint at a low temperature thus giving minimum heat effect on the parent metal. The amount of Ag solder required for a joint is less than with base metal solders. The Ag solder bond in brass, Ni-silver, Cu and stainless steel is shown in micros. Tensile strengths of 40 to 60 thousand lbs./in.^{2} obtained with 6-34% elongation in 2". Some tests on fluxes are reported. MS + WB (7a)

7b. Welding & Cutting

E. V. DAVID, SECTION EDITOR

The **Welding of Chassis Frames.** H. S. BAVISTER. *Sheet Metal Industries*, Vol. 9, June 1935, pages 395-396. Condensed from a paper read at the Symposium on the Welding of Iron and Steel. A discussion of the use of the Sciaky welding process in which high pressure is applied and drops off as the welding current is established to be re-applied with the cutting off of the welding current. This gives a forging action on the finished weld. AWM (7b)

Modern **Resistance Welding.** P. W. FASSLER. *Automobile Engineer*, Vol. 25, Sept. 1935, pages 327-328. Advantages of butt, flash, spot and projection welding in particular for quantity production in the automobile industry are described. Ha (7b)

Economical **Welding Procedure in the Shop.** HAROLD VERSON. *Welding Journal*, N. Y., Vol. 14, July 1935, pages 8-9. Machine construction by welding processes, design and machining problems are discussed in the text. WB (7b)

Rail **Welding on Bridges (Schienenschweissung auf Brücken).** WATTMANN. *Organ für die Fortschritte des Eisenbahnwesens*, Vol. 89, Oct. 15, 1934, pages 377-384. Mathematical treatment of the longitudinal stresses in bridges incorporating rails with welded joints. Various cases are calculated and the stress distribution is clearly shown in 9 illustrations. WH (7b)

Welding of Steels of High Strength (Das Schweissen von Stählen grosser Festigkeit). K. L. ZEYEN. *Technische Mitteilungen Krupp*, Vol. 3, Aug. 1935, pages 176-188. The difficulties of welding C and alloy steels encountered in fusion and arc welding by changes in the material are explained and tests described. The development of steels insensitive to welding is discussed. Mn steels with higher C content can now be arc welded. Ha (7b)

Chemical Composition of Welding Rods and Its Change in the Welding Process (Die chemische Zusammensetzung von Schweissdrähten und ihre Veränderung bei der Schweissung). K. L. ZEYEN. *Technische Mitteilungen Krupp*, Vol. 3, June 1935, pages 112-125. The importance of suitable chemical composition of the welding rod for the quality of the weld is pointed out and the standards of composition adopted by the German State Railways for gas fusion and electric welding given in a table. Experiments are described for greatly increasing the mechanical properties of a weld by proper composition of the coating of the electrode with deoxidizing substances which gasify in welding and create a protective atmosphere around the arc. Procedure most favorable to satisfactory welds (one or more layers) is discussed, and micrographs show the structures as influenced by welding rod composition and procedure. Ha (7b)

Welded Steel Frames for Marine Engineers. C. H. STEVENS. *Transactions Institute of Marine Engineers*, Vol. 67, Part 2, Mar. 1935, pages 39-52, *discussion*, pages 52-59. Paper before the Institute of Marine Engineers, London, Feb. 12, 1935, deals with the design and production of welded steel frames for marine oil engines of the 4-stroke type for main and auxiliary purposes. The method of construction in which primary loads are not transmitted through the welding is explained and its application in the designs illustrated. A description is given of 3 types of frames as actually constructed for main engines, together with line drawings and photographs of the frames in various stages of construction. Some auxiliary engines are also described and illustrated in order to show the general adaptability of the method of design to varying sizes and types of engines. The advisability of separate cylinder water cooling jackets is mentioned and means suggested for such arrangement. The question of removal of the crankshaft for repair or renewal is discussed particularly in connection with welded steel frames. A large scale model was put together during the meeting to demonstrate how the plates are cut and fitted. The steel used in these frames is of 24-28 tons/in.^{2} tensile strength with a yield point of 14-16 tons/in.^{2} and an elongation of 25% in 8". The C content is low not exceeding 0.15%. This quality of steel is excellent for electric arc welding. The material weight savings obtained are stressed. See also *Metals & Alloys*, Vol. 6, July 1935, page MA 286L/4. WH (7b)

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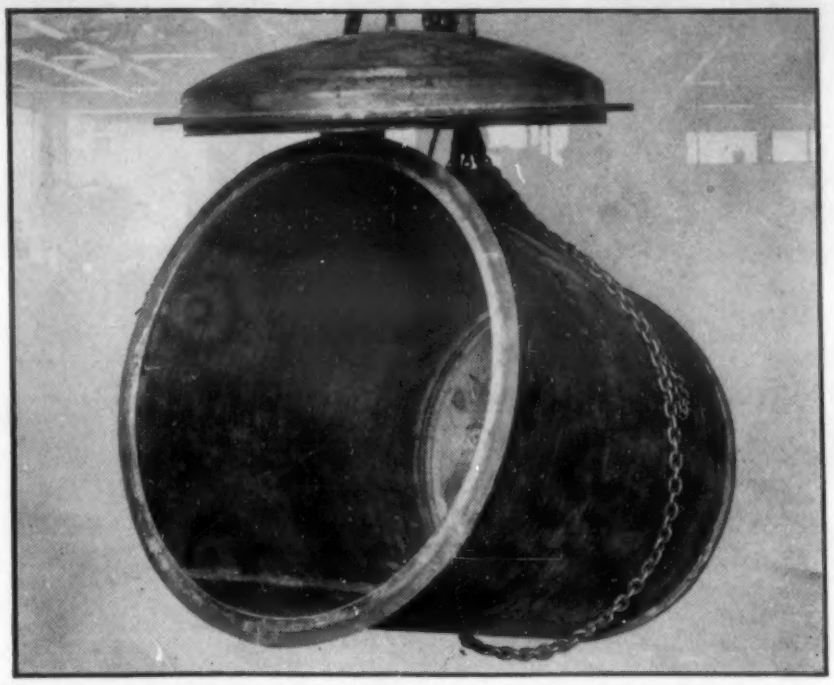

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MA 496

Electrically Welded Malleable Iron and Its Subsequent Treatment (Elektrisch geschweisster Temperguss und seine Nachbehandlung). TH. TILEMANN. *Giesserei*, Vol. 22, Aug. 2, 1935, pages 377-386. Arc welding of malleable iron requires a coated electrode with, preferably, an asbestos cover; it should have a soft core and an approximate composition of 0.2% C, 0.06% Si, 1.1% Mn, 0.02% P, 0.03% S within ± 10% margin. The coat should consist of 40-50% graphite, 1-5% Fe_2O_3, 20-25% SiO_2, 10-20% CaO, 0.6-3.5% MnO, 1.2-2.5% Al_2O_3, 0.8-2% MgO, 3-4% alkalies, no P_2O_5, and 30-50% losses by ignition. The electrode must be the positive pole. A current of 100 amp. at 25 v. can be used for wall thicknesses of from 4 to 20 mm., and white and black malleable Fe can be welded in this manner; the weld is dense, homogeneous and can be decarburized. Electric resistance butt welding can be applied with good results for white malleable Fe up to 15 mm. thickness; not so well for black malleable Fe. Slight forging of butt welds and subsequent annealing increases considerably tensile strength, elongation, toughness and machinability. Cooling in air or sand after welding of white Fe increases tensile strength and hardness and reduces elongation, toughness (bending angle) and machinability very little. Temper carbon usually does not affect harmfully arc and butt welds, the latter, however, in black malleable Fe, and is independent of wall thickness. For both kinds of malleable Fe weldability becomes better with decreasing total C, Si, P and S and increasing Mn content up to 0.5%. Subsequent annealing of arc and butt welds in kieselgur at 900° C. for 30 min. for white and for 2 hrs. for black malleable Fe produced the best values of tensile strength and hardness, but elongation and toughness were reduced by more than half; machinability was good. All butt welds must be treated subsequently to removal of excess weld material. Thermo-mechanical and metallurgical reasons favor only the electric arc and resistance butt welding for both white and black malleable Fe, but the weld should never be overheated. 12 references. Ha (7b)

Multiple Arc Welding Equipments. *Engineer*, Vol. 159, June 7, 1935, pages 601-602. Describes newly designed a.c. multiple welding equipment developed by the Oerlikon Company. For welding structural Fe parts a.c. is just as efficient as d.c. and stainless steel and bronze can be welded with a.c. when special electrodes are used. The efficiency of the a.c. equipment at full load is about 82% while that of d.c. equipment is about 46%, including the losses in the motor generator set. LFM (7b)

Welding of Cracks (Zum Verschweissen von Rissen). *Der Autogen-Schweisser*, Vol. 8, Apr. 1935, pages 44-45. A hole is drilled at end of crack to prevent notch effects and stress concentrations in castings. In rolled structural members, region at end of crack is first preheated before the crack is welded. WH (7b)

Various Lead Welding Jobs Done with the Oxy-Acetylene Torch (Die Ausführung von verschiedenen Bleischweissungen mit dem Azetylen-Sauerstoff Schweissbrenner). *Der Autogen-Schweisser*, Vol. 8, Apr. 1935, pages 37-39. A torch of 50 l./hr. capacity held at 45° over the work and 1-2 mm. higher than normal is used. Six different kinds of welding procedures are fully considered. A chart presents data on these welding methods interrelating Pb sheet thickness, O_2 and C_2H_2 consumption and welding speed. WH (7b)

Tin Soldering or Gas Welding (Löten mit Zinn oder autogenes Schweissen). *Der Autogen-Schweisser*, Vol. 8, Apr. 1935, pages 39-40. In the chemical industry, gas welding is preferred for joining Pb due to the larger corrosion resistance of welded seams. Soldering is widely applied in the plumbing trade mainly due to conservatism. Briefly reports on tests carried out by the Office Central de l'Acétylène et de la Soudure Autogène which show that gas welding can be done 20% faster. A portable gas welding outfit weighs only 21 kg. WH (7b)

Welding in Relation to the Manufacture of All-Steel Automobile Bodies. J. C. ARROWSMITH. *Sheet Metal Industries*, Vol. 9, May 1935, pages 328-330. General discussion of spot and seam welding as applied to body manufacture. AWM (7b)

Developments in Railway Engineering with Particular Reference to South Australia. C. B. ANDERSON. *Journal & Transactions Institution of Engineers of Australia*, Vol. 7, June 1935, pages 217-221. A special chapter is devoted to permanent way developments which largely refer to welding in railway track work, crossings, wing rails and reconditioning of defective rail joints as practiced in South Australia. WH (7b)

The Special Welding Process of Krupp, DRP 567,094 (Die Krupp'sche Sonderschweissung DRP 567,094). E. BECKMANN. *Technische Mitteilungen Krupp*, Vol. 3, Aug. 1935, pages 137-142. **The Development of Austenitic Welding (Die Entwicklung der austenitischen Schweissung).** K. KAUTZ. Pages 143-173. **Can Weld Seams of Nobler Material Decrease the Life of Boiler Plate? (Können Schweissnähte aus edlerem Werkstoff die Lebensdauer von Kesselblechen herabsetzen?).** C. CARIUS. Pages 173-175. The new process is characterized by 3 principal points: (1) Non-aging steel is used as base material. (2) The electrode gives, without subsequent heat treatment of the weld, excellent values of tensile strength, elongation and notch toughness. It is in welded condition also non-aging and has the same expansion coefficient as the base material. (3) No annealing to remove (interior) weld stresses is required. The method is applied particularly where very high demands are made on the welded joint. Homogeneity of weld, transition zone and base material is obtained by the use of an electrode of high Ni and Cr content which has an austenitic structure in welded state. Metallographic, metallurgical and technological properties are discussed in full and illustrated by numerous curves and micrographs. The high plastic and elastic deformability and the notch-insensitiveness of the austenitic weld are particularly advantageous for reduction of interior stresses; views so far held of the use of non-aging and tough materials on account of dangerous interior stresses have been found to be baseless. It was furthermore found that no danger of corrosion exists which might occur as a result of local elements between weld and base materials on account of potential differences. Tests with hot boiler water containing O and of 160-190° C. showed a loss of material of only about 0.002 g./cm.²/yr., for a surface ratio of weld to plate of 1 : 100, and of 0.004 g./cm.² for 1 : 50, so that about 100 yrs. would be required before the plate had lost ¾ or ½ mm. due to electrolytic phenomena. The new process can, therefore, be employed for boiler plate welded with the special electrode. The composition of the latter is about 0.09% C, 0.78 Si, 1.31 Mn, 19.9 Ni, 25.2 Cr, 0.019 N_2 and 0.040 O_2. The weld showed a composition of 0.20 C, 0.35 Si, 1.86 Mn, 18.4 Ni, 22.3 Cr, 0.044 N_2 and 0.050 O_2. Data for dimensions of electrodes and currents to be used are given. Ha (7b)

Welded Steel Structures—Recent Developments in Europe. *Structural Engineer*, Vol. 13, Feb. 1935, pages 73-80. Discussion on recent paper by A. R. Moon before Institution of Structural Engineers. Bylander describes welding on existing cast Fe columns in a warehouse for reinforcement purposes. Bondy discusses different construction principles favored in various countries. In the U. S. A. engineers prefer to use rolled steel joists on steel frames, in Belgium the Vierendeel truss prevails and in Germany the preference is for rigid corner joints wherever possible. Chilton states that stiffeners are designed on rather arbitrary principles. The bulb stiffener instead of the tee stiffener offers no advantage. Simmonis refers to welding regulations as follows: In Germany, there was a tendency to help from the rolling mill with the formation of the steel for welding. The regulations threw a great deal of onus on the contractor. In America the tendency prevailed "so long as they could get quantity of metal into the weld everything was all right." In England, where only one reasonable welding code exists, the responsibility is thrown too much on the electrode and too little on the contractor. (See also *Metals & Alloys*, Vol. 6, July 1935, page MA 286L/6). WH (7b)

An Industrial High-Pressure Boiler with Welded Drums. *Steam Engineer*, Vol. 4, July 1935, pages 430-432. The first welded boiler drum in Great Britain is described. AHE (7b)

Welded Construction of Riveting Machines. *Mechanical World & Engineering Record*, Vol. 47, Apr. 19, 1935, page 374. Describes and illustrates the welded construction of a 45 ton scissors type riveting machine and a gap riveting machine of 50 tons capacity. Welding for such machines has been found to have several advantages over the use of castings, which often fractured at the knuckle joint due to initial stresses set up during the cooling in the foundry. Operators prefer the welded machine as being lighter and handier without having any additional spring. The latter requires no pattern; it can be made more quickly and there is no loss of time due to defective castings. WH (7b)

Applications of Fusion Welding in Building Construction (Applications de la Soudure Autogène dans les Constructions Immobilières). E. Mopin. *Bulletin de la Société des Ingénieurs Soudeurs*, Vol. 6, May-July 1935, pages 1773-1795. Lecture before French Welders' Society. Describes typical applications in large constructions in the neighborhood of Paris. FR (7b)

Autogenous Rail Joint Welding (Autogene Schienenverbindungsschweissung). Hans Melhardt. *Der Autogen-Schweisser*, Vol. 8, May 1935, pages 49-54. Electric and gas welding are equivalent joining methods for rails. Impact and dynamic strength values are better for the latter method. Analyses of the resistance moments and bending stresses in a fish-plate joint are shown in diagrams and conclusions are drawn in regard to the proper method of welding rail ends. The novel "Böhler X-joint" is stressed. The latter failed at 24,833 kg. (mean value of 3 measurements) in a bending machine while the fish-plate joint broke down at 10,650 kg. It is pointed out that the gas-welded joint is no more expensive than the electrically welded one. Detailed cost sheet (Austria) is included. WH (7b)

Experiences of a Practical Man with Repair Welding of Steam Boilers (Erfahrungen eines Praktikers über Dampfkessel-Reparaturschweissungen). Robert Otto. *Autogene Metallbearbeitung*, Vol. 28, Aug. 1, 1935, pages 233-234. A few remarkable cases of repair of boilers, fire boxes, etc. by welding are described and the procedures advisable in each particular case are discussed. Ha (7b)

The Welding of High Tensile Steels. J. Orr. *Mechanical World & Engineering Record*, Vol. 47, Apr. 12, 1935, pages 349-350. High tensile steels now are being used with the object of lightening structures. Testing results given on the following 5 steels indicate possibilities of welded fabrication:

C	Mn	Cr	Ni	Cu
.25	1.5	—	—	—
.28	1.0	—	—	0.5
.28	0.8	0.6	—	0.5
.35	1.1	0.6	—	—
.19	0.6	—	1.9	—

WH (7b)

Electric Arc Welding in General Engineering. J. Orr. *Transactions Institution of Engineers & Shipbuilders in Scotland*, Vol. 78, Apr. 1935, pages 337-356. Discussion. For abstract of paper see *Metals & Alloys*, Vol. 6, Aug. 1935, page MA 327L/3. JCC (7b)

The New Welded Metal Bridges of Stockholm (Sweden) (Les Nouveaux Ponts Metalliques Soudés de Stockholm (Suède). N. E. W. Nilsson. *Bulletin de la Société des Ingénieurs Soudeurs*, Vol. 6, May-July 1935, pages 1824-1832. Lecture before the French Welders' Society. Descriptive lecture accompanying presentation of moving pictures. FR (7b)

Micro Testing Machines for Study of Welds. Albert M. Portevin. *Metal Progress*, Vol. 28, July 1935, pages 49-51. Conventional tests of a complete joint or standard specimen cut from it give on the average results of a heterogeneous whole but by use of small specimens 1.5 mm. dia. x 7.0 mm. gage length evaluation of homogeneity may be obtained and weld structures developed in quality. Metallographic methods and hardness tests with small indenter are useful but fail to evaluate ductility or shear strength. Equipment with photographic recording means for tests of such small specimens is described. Graphs show the distribution of physical properties, 4 points to the inch, over a distance of 5 1/2" for a 9/16" joint in a steel, C 0.31%, Cr 1.0%, Mo 0.36%, with the weld bead in the fourth inch. Marked minima are noted in strength and yield under tension and shear in 2nd and 4th inches without loss of ductility. WLC (7b)

Preliminary Statement on the Mechanism of Chemical Reactions in Weld Metal. J. H. Patterson. *Welder*, Vol. 7, May 1935, pages 546-547, 575. The fact that electric welds made with bare electrodes absorb a great amount of N and cause great hardness in the weld is commented on. A coated electrode with coating containing 1.6% of dry wood flour reduced hardness and also the N content which was only 0.04% against 0.12% with the bare electrode. Ha (7b)

Fusion Welding at the Paris Fair (La Soudure Autogène à la Foire de Paris). R. Salelles. *Revue de la Soudure Autogène*, Vol. 27, June 1935, pages 2-12. Reviews all applications, tools and machines. FR (7b)

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8. FINISHING

H. S. RAWDON, SECTION EDITOR

Finishing Metal Products. HERBERT R. SIMONDS. McGraw-Hill Book Company, New York, 1935. Cloth, 6 x 9¼ inches, 337 pages. Price $3.50.

In the words of the author "the average manufacturer knows less about finishing than about any other link in his production chain." This book has been offered "in the hope that it will point the way to more attractive finishes and to more efficient means for producing them." The first part of this aim, at least, has been admirably accomplished.

The scope of the work is exceedingly broad and necessarily in a book of the length of this one, a detailed treatment can be given to none of the subjects discussed. Part I is devoted to an excellent exposition of the commercial aspects and sales value of metal finishes. This is followed in Part II by a discussion of the various phases of the preparation of metal surfaces prior to the application of the finish. Succeeding parts cover polishing and buffing the treated surfaces, plating and sprayed coatings, painting, and special finishes. Each part consists of several chapters.

The subject matter is exceptionally clearly presented and should appeal especially to executives, superintendents, and others who are interested in generalizations and results rather than in details of operation. The author has done an outstanding job in presenting the essential salient features of the various subjects dealt with. One finishes a chapter with much the same feeling of satisfaction that he has after having been shown personally through a manufacturing plant by a very competent guide.

The book differs decidedly from the usual technical book in the absence of references to the work of other investigators which one might wish to consult to supplement and extend the author's presentation. The repeated references which the author makes throughout to the advice and conclusions of experts, usually one or two in each of the different fields discussed, without any further reference to published work, is somewhat irritating to the technical reader. However, since all industrial research is intended to lead ultimately to some useful applications, the book should prove valuable to research workers on metal products if only for the wealth of suggestions it contains.

A feature which will appeal particularly to the practical man is the use of trade names for materials and processes, such as "deoxidine," "bonderizing," etc., together with sources from which certain special or unusual materials may be obtained. The lack of definite information concerning the nature of many of these processes, however, is another source of provocation for the technical reader.

The present reviewer has read the book with genuine interest and concludes that it will prove a valuable asset to metal manufacturers and others who are at all concerned with the finish of the completed article especially as this is reflected in "sales appeal." The author's object in showing that surface appearance is an important item giving sales value and that "the finishing of metal products is a highly important factor in the total production and distribution sequence" has been very convincingly set forth. H. S. Rawdon (8) -8-

8a. Pickling

Bullard-Dunn Metal Descaling Process. COLIN G. FINK & T. H. WILSER. *Iron Age*, Vol. 134, Oct. 25, 1934, pages 24-27. From a paper read before the Electrochemical Society. See *Metals & Alloys*, Vol. 6, Oct. 1935, page MA 404L/8. VSP (8a)

8b. Cleaning, including Sand Blasting

Electrolytic Degreasing (Die elektrolytische Entfettung). FRITZ SCHÄFER. *Metallwaren-Industrie & Galvano-Technik*, Vol. 32, Sept. 15, 1934, pages 408-409. Directions for electrolytic degreasing of metallic parts prior to electroplating are given with full description of the degreasing and rinsing operations. EF (8b)

8c. Polishing & Grinding

Abrasives are Used in the Foundry. EDWIN BREMER. *Abrasive Industry*, Vol. 16, Aug. 1935, pages 8-11. Description of operations for grinding nonferrous and malleable iron castings. Most efficient wheel speeds and type of grit are discussed. WB (8c)

Measuring and Specifying Surface Finish. E. J. ABBOTT. *Metal Treatment*, Vol. 1, Summer 1935, pages 92-94, 101. Slightly abridged reprint from *Journal of the Society of Automotive Engineers*, Mar. 1935. See "Surface Finish and How it can be Measured and Specified," *Metals & Alloys*, Vol. 6, May 1935, page MA 196L/9. JCC (8c)

The Rail-Sled Grinder (Der Schienen-Schleifrutscher). FRITZ KNACK. *Verkehrstechnik*, Vol. 16, Jan. 20, 1935, pages 41-42. The pros and cons of the rail-sled grinding method are pointed out. Six macro-structures are discussed with reference to grinding of rails. Seven other illustrations show the shape and mounting methods used for rail grinders. WH (8c)

Notes on Polishing and Buffing Special Metals. R. S. LEATHER. *Platers' Guide*, Vol. 31, Aug. 1935, pages 19-20. Resumé of precautions to be taken in polishing plates of Cd, Cu, Cu-pewter ware, and other soft metals, also Pt, Pb, Pb-Sb alloys. Britannia metal, and sheet Sn. WHB (8c)

8d. Electroplating

Improvement in the Quality of Tinplate by Superimposed Electrodeposition of Tin. A. W. Hothersall & W. N. Bradshaw. *Journal Society of Chemical Industry*, Vol. 54, Sept. 20, 1935, pages 320T-326T. Sn coatings formed on steel by the hot-dipping process are invariably porous or discontinuous, regardless of their thickness. Pores are obviously objectionable from the standpoint of corrosion, by electrolysis between the steel base and the Sn coating and by the action on the exposed steel, with ultimate perforation. A method of electrodeposition of Sn is described which is said to produce a coating of minimum porosity, even under bending. Following are the essential characteristics of the method: (1) Adequate preliminary cleaning: immersion in a boiling 1% solution of $Na_2Si_4O_9$. (2) Low current density: 15 amps./ft.^{2} appeared slightly inferior to 5 amps./ft.^{2} and markedly superior to 45 amps./ft.^{2} (3) Plating solution: $Na_2SnO_3.3H_2O$, containing 60-80 g. Sn/l. and 20 g. NaOH/l., bath temperature 70-75° F. (4) Deposition rate: for sheets, 2.8 g. Sn/m.^{2} in about 1.3 min. at 15 amps./ft.^{2} Severe local porosity produced by bending tinplate may be eliminated by electrodeposition. The deposition of 11.2 g. Sn/m.^{2} practically eliminated porosity on all bends made at right angles to the direction of rolling; 45 g. Sn/m.^{2} were required to eliminate porosity on bends made parallel to the direction of rolling. The article gives numerous tables of data, photomicrographs and photographs. AAA (8d)

Electrolytic Nickel-Iron Deposits. (Galvanische Nickel-Eisen-Niederschlage). E. Raub & E. Walter. *Mitteilungen des Forschungsinstituts und Probieramts für Edelmetalle*, Vol. 9, May/June 1935, pages 17-21. The question whether it is possible to produce durable, corrosion-resisting Fe-Ni deposits was further investigated; former experiments (*Zeitschrift für Elektrochemie*, Vol. 31, Mar. 1935, page 169) had shown this to be feasible with very acid baths, pH = 3, although H evolution is strong and current efficiency low. Addition of salts of alkyl-naphthalene-sulpho acid prevents pitting by H absorption of the deposits which is the usual consequence of the H formation. Fairly good results are obtained by increasing the bath temperatures to 70°-100° C. Absorption of H by the deposits was thereby reduced considerably. The Ni content of the deposit increases with higher temperatures. While at low bath temperatures the ratio of Ni to Fe in the deposit is smaller than in the bath, the reverse occurs at sufficiently high temperatures, and at 100° C. about only 5.5% Fe was found in the deposit from a bath containing 55% Fe. The duration of deposition did not change this condition appreciably as the table shows:

	Fe content of bath % of total metal content	Bath temp. ° C.	Time of deposition, min.	% Fe in deposit
Bath 1	12.0	20	10	54.8
		70	30	39.8
		20	10	32.8
		70	30	36.3
		20	120	53.3
		70	120	33.5
Bath 3	32.8	100	5	14.6
			60	12.8
Bath 4	50.0	100	30	15.9
Bath 5	55.1	20	15	63.0
		100	15	5.4

Increase of bath temperature contributes to the uniformity of the deposits which at low temperatures show layers of Ni and Fe but which are entirely uniform at 70° C. and above. Also pitting due to H absorption disappears almost completely. The mechanical properties of Ni deposits improve little with increasing temperature. They are rather brittle at 80° C. but the Fe-poor deposits at 100° are mechanically good. As the deposits are very porous, they begin to rust under atmospheric conditions after 20-50 hrs. Such deposits do not protect an Fe base and the deposition of an intermediary layer of Cu did not result in much improvement. Ha (8d)

Lustrous Cadmium Electro-Platings. *Synthetic & Applied Finishes.* Vol. 6, Apr. 1935, pages 16-18; May 1935, pages 44-47. Cd competes with Zn as a "sacrificial" protective coating notably under marine conditions, whereby Cd exhibits a considerably lower rate of dissolution. Owing to its higher electrochemical equivalent, Cd can be deposited twice as fast as Zn. The amount of Cd per unit surface is less than Zn for the same protection value. Cd is slightly more dense. Brilliantly lustrous finishes of Cd are obtained by suitable additions to the plating solution or by simple after-treatments, e.g., light wire brushing while wet or by lightly buffing it when dry. A recent more economic Continental practice is a final acid dipping. (HNO_3 H_2SO_4, or chromic acid). A typical 7-step operation including solution for soda wash, electrolytic degreasing, acid pickling for light scale and rust removal, electrolytic cyanide treatment, Cd plating, acid brightening and organic coatings is fully described including the analyses. Clean working conditions and the absence of foreign metal contaminations are stressed throughout. The chromic/sulphuric acid treatment is fully discussed and results given of corrosion tests made in the Duffek apparatus on 4 Cr-plated samples submitted to brightening treatment and finished off regularly. Recipes on the Grasselli process are given, stressing the additions of metallic brighteners to Cd plating solutions. Spray test results on durability of Cd coatings produced by 8 different processes are tabulated. EF (8d)

The Definition of Polarization, Overvoltage and Decomposition Potential. W. Blum & G. W. Vinal. *Transactions Electrochemical Society*, Vol. 66, 1934, pages 359-367. By taking electrolysis of water, with smooth platinum electrodes, as a typical example, the fundamental components of the cell or bath voltage are interpreted. Thereupon revised definitions are proposed and are discussed at length. The following recommendations on the use of terms are submitted: 1. "Equilibrium reaction potential" is preferably used to refer to the potential based on the free energy of the process; 2. "decomposition potential" is the minimum potential required for continuous electrolysis; 3. "polarization" includes all departures of the potential from the equilibrium potential, and is a measure of irreversibility (excluding IR drop) regardless of whether the products are solid, liquid, or gaseous; 4. "overvoltage" preferably refers to the minimum polarization required for any electrode process to occur at an appreciable rate under given conditions. (8d)

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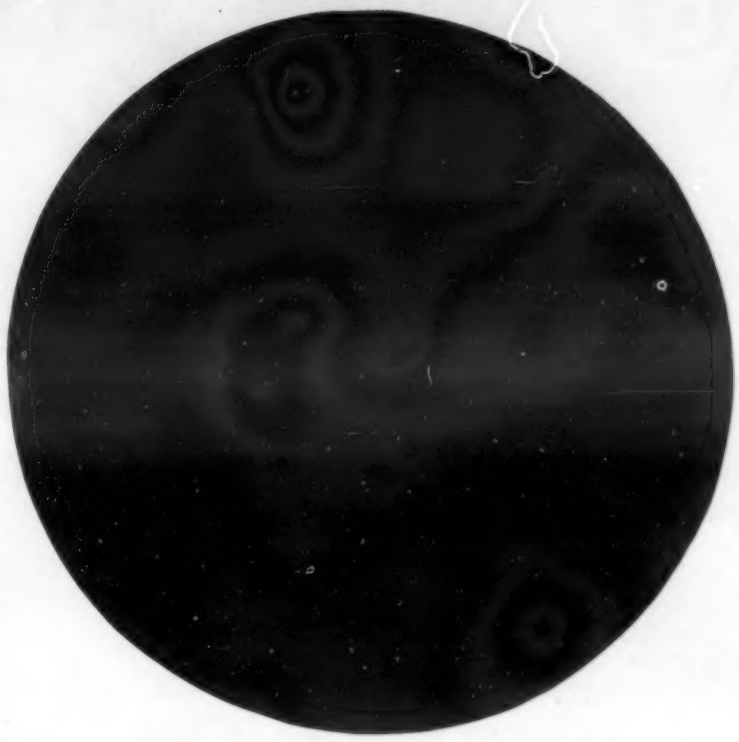

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8e. Metallic Coatings other than Electroplating

A New Method of Improving Surface Quality of Castings (Eine neue Methode der Oberflächenveredelung von Gussstücken). A. KARSTEN. *Giesserei*, Vol. 22, Aug. 16, 1935, pages 411-412. Instead of welding on to the surface layers of hard materials which is always difficult to do neatly and obtain uniform denseness, a modified spraying process is described by which uniform, wear-resistant surfaces can be obtained. A wire of alloy steel is volatilized in the spraying pistol at the proper temperature; the layers are claimed to be equal to those produced by arc welding, and to adhere perfectly. Examples of repairs are given. Ha (8e)

Hard-Zinc Formation (Hartzinkbildung). H. MEYER VON DER HEYDE. *Metallwaren Industrie & Galvano-Technik*, Vol. 33, Feb. 15, 1935, pages 74-75. The formation of hard Zn (95.25% Zn, 1.25% Pb, 3.50% Fe, traces of Sn, Cu, Al, Cd) is attributed mainly to overheating of the Fe melting kettles and to a smaller extent to contamination by iron tools and objects introduced into the Zn bath for coating. A temperature of 495° C. is pointed out as very favorable for the solution of Fe in Zn. EF (8e)

Zinc Ammonium Chloride, Its Place in Modern Galvanizing. H. G. HOBBS. *Iron Age*, Vol. 135, May 23, 1935, pages 10-13, 84, 86, 88, 90; June 13, 1935, pages 22-27, 90; Vol. 136, July 18, 1935, pages 18-21, 92, 94. Reviews the history of Zn up to the time of its use for hot-galvanizing, growth and mechanization of hot-galvanizing process, and various applications in galvanizing industry of HCl, NH_3, $ZnCl_2$ and NH_4Cl. Describes modern practice and advantages and disadvantages of $ZnCl_2.5NH_3.H_2O$ as against NH_4Cl and HCl. The application of $ZnCl_2.5NH_3.H_2O$ as a flux in galvanizing pipe, nails, wire, buckets, boilers, drums and line hardware is discussed. VSP (8e)

Zinc Galvanizing. (I), (II). EDMUND R. THEWS. *Canadian Chemistry & Metallurgy*, Vol. 19, May 1935, pages 137-138, 142; June 1935, pages 165-167. All grades of galvanizing Zn should meet the following specifications: (1) produce a minimum of ashes or dross during melting and galvanizing, (2) produce uniform, smooth and bright coatings which exhibit a good appearance generally, (3) these qualities must be permanent, (4) they must be attainable at a minimum thickness of coating without interfering with other requirements such as freedom from porosity, resistance to corrosion, etc., (5) they must be attainable at as low a galvanizing temp. as possible (850°-875° F.). The undesirable effects of Sb and As and Fe are noted together with the beneficial effects of Pb and of Sn. Sn content of 0.25-.50% or even of 0.60% produces brighter, smoother, and lighter coatings, increases the fluidity of the bath, and improves resistance to scratching and general wear. Cd resembles Sn in its effects, but its max. content is much lower. Al can exert a beneficial action only if present together with suitable quantities of Pb, Sn and Cd. The degree of purity is not a sure indication of suitability for galvanizing. Fluctuations of galvanizing conditions affect a normal galvanizing Zn less seriously than a very pure grade of Zn. WHB (8e)

8f. Non-Metallic Coatings

1 **Eloxal Process (Las Eloxal-Verfahren).** *Metallwaren Industrie & Galvano-Technik*, Vol. 32, Dec. 1, 1934, pages 517-519. The electrolytic oxidation of Al and its alloys is discussed at length and the properties (adhesion, color, hardness, thickness, chemical resistance, insulation and physical properties) of eloxal films are considered. The latest advance represents the production of films which are immune to the effects of temperatur and light. The current consumption varies between 3.5 and 15 kwh./m.² surface treated. EF (8f)

2 **Metallizing in Industry.** J. W. HISHON. *Metallizer*, Vol. 3, Apr. 10, 1935, pages 2-4, 8. The uses and advantages of metal spraying in the electrical, rubber, food and other industries and in foundry work are discussed. Carbon resistor contacts and motor brush contacts are now made by spraying with Cu. Metallized radio tubes are made by spraying Zn directly onto the glass surface. Airplane batteries are shielded from radio interference by spraying the cases with Pb, Sn or Al; wooden instrument cases and radio cabinets are similarly shielded. In the foundry, surface defects of castings, porous spots and small blow holes may be filled by metal spraying and patterns may be surfaced or repaired in the same manner. Sprayed Cu on new cast Fe patterns aids in withstanding the abrasive action of sand and in sand removal. Permanent molds are readily calorized by spraying with Al and heating. Al sprayed Cu, brass, or bronze inserts prevent blow holes when used in casting Al. For intricate patterns metal sprayed plaster, wood and wax forms may be used. Sand cores may be steel coated to eliminate blow holes and resist the flow of molten metal. Barrels made cheaply from galvanized sheeting with welded joints are finished by Zn spraying the joints. BWG (8f)

3 **The Protection of Steelworks by Paint.** W. E. HIGHFIELD. *Engineering*, Vol. 139, Feb. 15, 1935, pages 177-178; Feb. 22, 1935, pages 205-206. Structural work to be protected usually consists of C steel, in the form of rolled joists, angles, plates, bars, etc. The protective coating used should be from 0.008" to 0.01" thick, waterproof, unaffected by sunlight and remain elastic and keyed to surface of metal. Discusses the action of weather on steel, preparation of the material for painting, method of applying the paint and the kind of paint to use. VSP (8f)

4 **Synthetic Enamels as Bake Finishes.** RAY C. MARTIN. *Industrial Finishing*, Vol. 10, May 1934, pages 13-14. Discusses the methods of applying and baking one-coat and two-coat enamels. JN (8f)

5 **Parker Rust Proof Process (Das Parker Rostschutz-Verfahren).** W. OVERATH. *Metallwaren-Industrie & Galvano-Technik*, Vol. 32, Aug. 1, 1934, page 337. Detailed description of Parker process and corrosion data obtained in 3% NaCl spray tests on plain, Ni and Cr plated samples, and on 4 differently finished parkerized steel sheets. EF (8f)

6 **Aircraft Finishing.** M. W. MASON. *Industrial Finishing*, Vol. 10, Mar. 1934, pages 18, 20, 22; Apr. 1934, pages 16, 18, 20; May 1934, pages 16, 18, 20; June 1934, pages 32, 34-35. A combination of clear and pigmented "dopes" is used in airplane finishing. Aircraft finishes must withstand engine vibration, salt air, fog, sunlight, and moisture and temperature changes, as well as impact of wind, rain and hail and abrasion in polishing. Cellulose nitrate "dopes" are used more widely than cellulose acetate. These "dope" finishes protect the metallic framework, strengthen and water-proof the fabric, and add to the general appearance and visibility of the airplane. The method of cleaning the framework, attaching the fabrics, and applying the "dope" are described in detail. Metal work is Parkerized, Bonderized, plated with Cd or treated anodically. It is then primed, surfaced and polished. The fabric is sprayed or brushed with 4 to 6 coats of clear dope and finished with a color-pigmented or Al-pigmented dope. Damages to metal and fabric are repaired and lettering and decorations applied. Efficient methods of color coverage are discussed. JN (8f)

7 **Enameling in the Electric Furnace (L'Emaillage au Four Electrique).** *Electricité (Science et Industrie)*, Vol. 19, Apr. 1935, page 167. General article FR (8f)

8 **Recent Developments in Latex Coatings. Part I, Part II. Latex Paints and Protective Coatings. Part III.** P. CROXLEY. *Paint, Colour, Oil, Varnish, Ink, Lacquer Manufacture*, Vol. 4, May 1934, pages 154-155; June 1934, pages 179-181; July 1934, pages 218-219. Review of recent developments in the use of rubber latex in production of paints, distempers and coating compositions. A list of references and patents on the use of latex in paints is appended. EF (8f)

9 **Theory of Blistering of Cast Iron Enamels.** H. D. MCLAREN. *Enamelist*, Vol. 12, July 1935, pages 6-7, 46, 60. Blisters in the finished coat of enamel are usually caused by CO_2 and CO gases evolved from the surface of the cast iron. It can be cured by annealing the castings before they are enameled so that the combined C in the hard casting skin is broken up and later evolution of gases prevented. Use of a cast iron with as low a combined C content as possible is recommended. A composition which has a skin readily removable by sandblasting or grinding is: total C 3.25, graphitic C 3.0, combined C 0.25, Si 3.0, Mn 0.45, P 0.9, S 0.1 or less. The Fe should be poured at as low a temperature as possible. Ha (8f)

10 **Investigation of Methods for Comparing Rust Protective Paints (Vergleichende Untersuchung von Rostschutzfarben).** H. HEBBERLING. *Oberflächentechnik*, Vol. 12, July 16, 1935, pages 171-172. Methods for testing rust protective paints are reviewed. Short-time tests can be a valuable supplement to long-time tests under service conditions but should never replace them. Tests with red lead as primer seemed to indicate that the saponification of the pigment is the actual cause of the protective action. The microscope is the best means for distinguishing between "active" and "inactive" pigments; the former, e.g., white lead, red lead or basic Zn paints, show in linseed oil a more or less rapid growth of crystals and more or less rapid saponification, whereas both of these characteristics are lacking in the inactive pigments. Photographs illustrate the conditions. 12 references. Ha (8f)

9. TESTING

The Installation and Maintenance of Thermo-electric Pyrometers. G. H. BARKER. *Metallurgia*, Vol. 12, June 1935, pages 57-58; July 1935, pages 87-89; Aug. 1935, pages 121-122. Directions for using thermocouples and optical instruments. JLG (9)

A Survey of Testing in the Precious Alloy Field, with Some Notes on the Testing Requirements for Duplex Alloys. THOMAS A. WRIGHT. *Preprint, American Society for Testing Materials*, June 1935, 21 pages. The applications of the eight "precious" metals, Ag, Au, Pt, Ir, Rh, Pd, Os, and Ru, are discussed in detail. From the viewpoint of testing the order of importance would be Au, Ag, Pt and Rh. The tests to be applied include, in order of present trade practice, assaying; analysis for formula; studies involving identity, character, thickness and distribution of plate and electroplate; tarnish, corrosion and wear-corrosion; hardness; and ductility, springiness, etc. The Pitkin wear-corrosion testing apparatus is described. The paper surveys the field with the purpose of laying a foundation for the standardization of tests of gold-clad material. It makes a plea for the standardization of the basic methods of testing by the Society and later its coöperation in setting up standards of quality. VVK (9)

9a. Inspection & Defects, including X-Ray Inspection

C. S. BARRETT, SECTION EDITOR

Elaborate Test System Should Follow Fabrication of Pressure Vessels. E. C. SCHUYLER. *Oil & Gas Journal*, Vol. 34, Aug. 1, 1935, pages 40-41. Welded pressure vessels should be X-ray inspected and stress relieved. VVK (9a)

Detection of Weld Defects by X-rays and Their Influence on the Mechanical Properties (Der Nachweis von Schweissfehlern im Röntgenbild und deren Einfluss auf die mechanischen Eigenschaften). W. TOFAUTE. *Technische Mitteilungen Krupp*, Vol. 3, June 1935, pages 125-127. See *Metals & Alloys*, Vol. 6, Apr. 1935, page MA 159L/2. Ha (9a)

Mechanical and Non-destructive Testing of Pressure Vessels and Welds with Particular Reference to Sub-zero Operation. R. K. HOPKINS. *Welder*, Vol. 7, June 1935, pages 593-605. The great advantages derived by compulsory X-ray testing as prescribed in American and British regulations are pointed out, testing methods and equipment described. When structures are called upon to work at sub-zero temperatures the changes in property occurring at low temperatures must be carefully taken into account; a table shows impact (Charpy) strength for several materials at +70° and —75° F. after different heat treatments. Ha (9a)

9b. Physical & Mechanical Testing

W. A. TUCKER, SECTION EDITOR

An **Experimental Investigation of Cracking in Mild Steel Plates and Welded Seams.** E. G. COKER & B. P. HAIGH. *Engineer*, Vol. 159, May 3, 1935, pages 457-458; *Engineering*, Vol. 139, May 3, 1935, pages 476-478, 485. Includes discussion. From a paper read before the Institution of Naval Architects, Apr. 1935. See *Metals & Alloys*, Vol. 6, July 1935, page MA 291L/4. LFM (9b)

A Machine for Brinell, Transverse and Shear Tests (Machine d'Essai Permettant l'Essai Brinell, l'Essai de Flexion Statique et l'Essai de Cisaillement). RENÉ GUILLERY. *Bulletin de l'Association Technique de Fonderie*, Vol. 9, June 1935, pages 183-189. Paper presented before the Association Technique de Fonderie, Mar. 20, 1935. Describes a testing machine for determination of hardness and transverse and shear strength on small specimens. WHS (9b)

The Determination of Young's Modulus for Building Materials by a Vibration Method. G. GRIME. *London, Edinburgh & Dublin Philosophical Magazine & Journal of Science*, Vol. 20, Aug. 1935, pages 304-310. A new method is described which makes possible the determination of elasticity (Young's modulus) for materials for which, due to their form, it is impossible to use the usual extensometer method. The free longitudinal vibration is measured in small specimens from which the elasticity is then derived by the formula $E = Al^2n^2\rho/(1-\pi^2\sigma^2K^2/2l^2)^2$, where l is the length of specimen, n, the frequency of longitudinal vibration, ρ density, σ Poisson's ratio, K, radius of gyration of cross section about the lines of centers of the normal sections. In most cases, the denominator may be neglected with sufficient accuracy. Ha (9b)

Tests and Testing. C. A. KELLOGG. *Wire & Wire Products*, Vol. 10, Sept. 1935, pages 411-413. A brief discussion of the points to be observed in testing and of testing methods. Ha (9b)

Influence of Recesses on Shafts Upon the Alternating Bending Strength (Einfluss von Hohlkehlen an abgesetzten Wellen auf die Biegewechselfestigkeit). E. LEHR & R. MAILÄNDER. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Aug. 17, 1935, pages 1005-1011. Characteristic figures were sought for determining the sensitivity of a material used in a shaft the diameter of which changes several times by transition recesses of smaller or greater radius; several C and alloy steels were used for the endurance tests. A Cr-Ni steel of high strength was much more sensitive for the notch-effect of the recess than a C steel with 0.28 C, while a nitrided steel showed an extremely low sensitivity. The sensitivity number is defined as the quotient of notch efficiency over shape value; the derivation is explained and calculated for several specimens of differing shapes. A further more exhaustive study of the subject is advocated. 12 references. Ha (9b)

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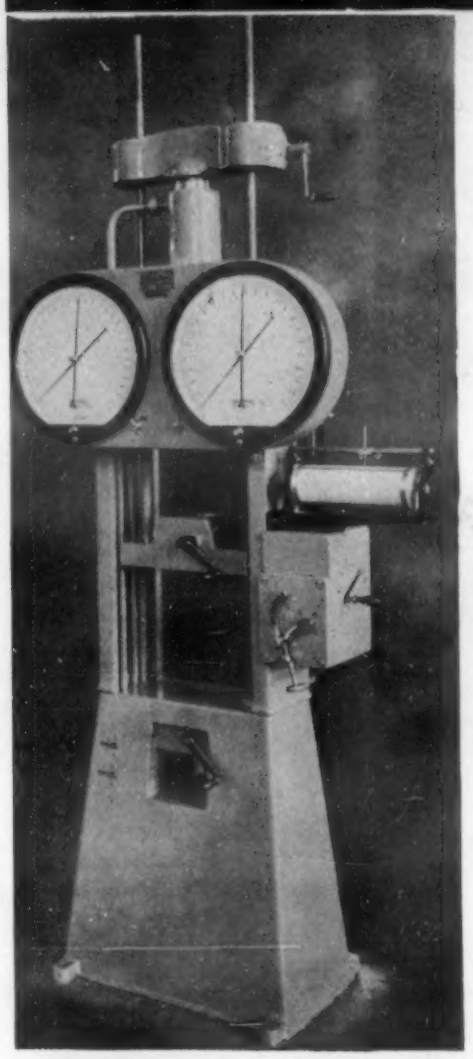

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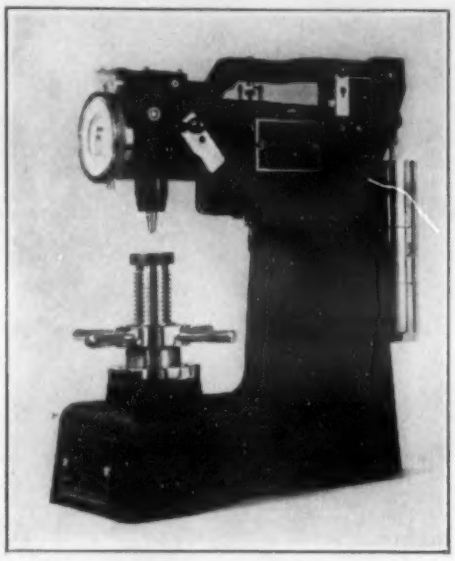

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9c. Fatigue Testing

H. F. MOORE, SECTION EDITOR

The abstracts appearing under this heading are prepared in cooperation with the A.S.T.M. Research Committee on Fatigue of Metals.

Endurance of Case Hardened Gears. O. W. McMullan. *Preprint, American Society for Metals,* Oct. 3, 1935, 12 pages. Results of dynamometer breakdown tests on rear axle drive gears and pinions for automobiles are given. In such tests the gear teeth and pinion teeth are subjected to repeated loading and to wear. Three types of failure were noted: (1) by wear so that gears became noisy, (2) by pitting and wear of pinion teeth, (3) by breaking out of ring gear teeth. Oil hardened steels without case hardening had high tooth strength in the gears but low resistance to wear in pinions. With S.A.E. steel 4615 was used in both gears and pinions failure occurred by fracture of ring gear teeth. A combination of double treated S.A.E. 4820 steel in gears and pot-quenched 4615 steel in pinions gave the longest life observed in any tests. In discussion the author stated that the load on the teeth during tests was 60% above the estimated maximum load on the teeth for normal operation of the automobile. HFM (9c)

Damping Capacity, a Factor in Fatigue. G. R. Brophy. *Preprint, American Society for Metals,* Oct. 3, 1935, 21 pages. The paper is one of the pioneer papers to study the correlation between the dying out of vibrations (damping) in a metal and its fatigue properties. The damping characteristics and endurance properties of several steels in several conditions of heat treatments have been determined and an attempt made to correlate these properties. Damping capacity seems to be related to the damage resulting to steel from overstress and notches. High damping steels (vibration dies out quickly) are resistant to sharp notches, but not to overstress, while low damping steels are resistant to overstress, but sensitive to notches. A limiting damping capacity, varying, it is believed, for different notches, is recognized. Below this limit, extreme notch sensitivity occurs. Several factors influencing these properties have been studied and among the most important are grain-size and structure. HFM (9c)

Corrosion Fatigue (La fatigue sous corrosion). L. Persoz. *Aciers Spéciaux, Métaux et Alliages,* Vol. 9, Oct. 1934, pages 311-328. After reviewing the published corrosion-fatigue works of MacAdam, Ludwik, Inglis, Mailaender, Gough and Buchholtz and Krekeler it is concluded that the presence and concentration of oxygen in the corrosive medium is very important in corrosion-fatigue of metals. The action of the corrosive medium (liquid or gas) during corrosion-fatigue, is very complex and yet not sufficiently known; it produces pits which make notches in the metal which in turn develop into local fatigue. The alternating load may break the protecting films and thus start corrosion. The principal problem of corrosion-fatigue depends upon the nature and the properties of the protective film formed. Tables and fatigue curves are reproduced listing corrosion fatigue tests on plain carbon steels, alloy steels, nitrided steels, stainless and non-ferrous metals. GTM (9c)

Fatigue in Helical Springs Made of "Superharmonic" Steel (I fenoment di fatica nelle molle ad elica in acciaio "superharmonico"). II. V. Prever & L. Locati. *La Metallurgia Italiana,* Vol. 27, Apr. 1935, pages 255-274. The new fatigue test described in part I has been applied in testing valve springs made from several typical "superharmonic" steels. Steels having the following composition:

	C	Mn	Si	Ni	Cr	P	S
1)	0.96	0.62	0.19	0.42	trace	0.037	trace
2)	0.68	0.56	0.23	—	"	0.035	"

were given complete tests, tests on wire made using these steels being compared with tests on springs. Static tests alone are not sufficient to distinguish suitable material, so they must be supplemented by dynamic tests (vibration or torsion). Medium tensile strength and hardness are to be preferred, i.e., 36-39 kg./mm.² tensile 44-47 R_W hardness (Rockwell hardness-cone, 150 kg. load) gave the optimum results. Annealing at 320° C. was found to produce better springs than when the annealing was carried out at 240° C., even though the latter gave higher tensile strength. A slight preliminary torsional set improves subsequent resistance to torsion. The charaeteristics required of a good spring steel are:— high C, about 0.70%; low P and S content, P plus S $<$ 0.06%; and medium, but uniform hardness. The causes of failure of springs were found to be distributed as follows:— local graphitization 20%; variation in hardness 10%; surface defects caused during wire-drawing 10%; local defects 12%; excessive hardness 10%; low tensile and low C (0.5-0.6%) 15%; excessive strain and other defects in construction 10%. AWC (9c)

The Relation of Fatigue to Modern Engine Design. W. S. Burn. *Engineer,* Vol. 160, July 5, 1935, pages 21-22; July 12, 1935, pages 48-50. From Part II of a paper by MacGregor, Burn & Bacon before the North-East Coast Institution of Engineers & Shipbuilders, Newcastle-upon-Tyne, Jan. 1935. See *Metals & Alloys,* Vol. 6, May 1935, page MA 200. LFM (9c)

Rapid Low Temperature Fatigue Tests. W. D. Boone & H. B. Wishart. *Iron & Coal Trades Review,* Vol. 131, July 19, 1935, pages 94-95. See *Metals & Alloys,* Vol. 6, Aug. 1935, page MA 331L/3. Ha (9c)

Rear Axle Gears—Factors which Influence Their Life. J. O. Almen & A. L. Boegehold. *Heat Treating & Forging,* Vol. 21, July 1935, pages 338-340. Paper read before the American Society for Testing Materials. See *Metals & Alloys,* Vol. 6, Aug. 1935, page 331L/1. MS (9c)

9d. Magnetic Testing

L. REID, SECTION EDITOR

The Effect of Phosphorus on the Magnetic Properties of Iron. Heihachi Kamura. *Tetsu-to-Hagane,* Vol. 21, Aug. 25, 1935, pages 643-655. In Japanese. Specimens were prepared from pure Fe reduced by H and pure Fe-P alloy. The magnetic properties of specimens containing 0.1-1% P and free from C were determined by means of ballistic galvanometer method. The small amount of P in Fe improves the magnetic properties of iron (that is, high permeability and low hysteresis loss) although other impurities are injurious to these properties. When the amount of P in Fe was about 0.7% the max. permeability reached 20,000 and the hysteresis loss decreased to less than 1,000 ergs/cm.²/cycle, which is nearly 3 times the max. permeability and 60% of the hysteresis loss of Si-steel containing about 3.5% Si. When P content was more than 0.5%, no magnetic aging phenomenon was observed. To obtain the best magnetic properties, the proper annealing temperature was found for different P contents; for example, for Fe containing low P proper annealing temp. is 900-950° and for that containing 0.7% P, 1050°. According to microscopic examination, the higher the P content in Fe, the larger the grain size as in the case of Si-steel, but it was not very noticeable when P content was more than 0.5%. When the annealing temp. rises to the A_3 transformation point in the equilibrium diagram of Fe-P system, deleterious effects on the magnetic properties are observed. TS (9d)

A New Twin Yoke Magnetic Steel Tester (Ein neuer Doppperjoch-Magnetstahlprüfer). F. Stäblein & R. Steinitz. *Technische Mitteilungen Krupp,* Vol. 3, June 1935, pages 129-135. The new method is based on the measurement of the magnetic flux in an auxiliary rotating coil in an air gap and is independent of shape of specimen. Its application is illustrated by the determination of the hysteresis curve of a Ni-Al steel with a coercive force of 550 oersteds. Ha (9d)

Magneto-Elastic Stress Determination in Iron Reinforcing in Concrete (Magnetoelastische Messung von Eisenkräften in Eisenbetonkörpern). E. Chwalla. *Beton & Eisen,* Vol. 34, May 20, 1935, page 163. The new instrument is based on the phenomenon that ferro-magnetic materials show typical changes of magnetization in relation to mechanical stresses. WH (9d)

The Variation with Magnetic Field and Temperature of the Thermoelectric Properties of Ferromagnetics. F. E. Lowance & F. Woodbridge Constant. *Physical Review,* Vol. 48, Aug. 1, 1935, pages 257-260. It was first shown by Sir Wm. Thomson that a thermocouple may be composed entirely of Fe or Ni provided part is in a magnetic field and part not. A survey of the work previously done on this subject and an experimental investigation of a more extended nature than any heretofore have been attempted in order to clear up existing confusion and render the subject more available to theoretical interpretation. Measurements on Fe, Ni, Co, and permalloy from room temperature to above the Curie point indicate that the e.m.f. produced by a magnetic field in these thermocouples is conditioned by (1) the crystal structure and (2) the change in direction of the resulting spins or intrinsic magnetization in separate crystal regions, and that this effect is related to the change in length on magnetization. WAT (9d)

The Size and Arrangement of Bismuth Microcrystals Formed from Vapor. C. T. Lane. *Physical Review,* Vol. 48, Aug. 1935, pages 193-202. The magneto-resistance of films of bismuth, deposited on glass and mica, has been measured at room and liquid-air temperatures and for various angles between the film normal and the magnetic field. The thermal coefficient of resistance shows no corresponding anomaly. X-ray analysis shows all the films to be composed principally of small crystals with (111) parallel to the backing. The bearing of these results on the structure of metallic films is briefly discussed. WAT (9d)

10. METALLOGRAPHY

J. S. MARSH, SECTION EDITOR

1

The Determination of Certain Phase Boundaries in the Silver-zinc Thermal Diagram by X-ray Analysis. E. A. Owen & I. G. Edmunds. *Journal Institute of Metals*, Vol. 57, June 1935, pages 321-330 (Advance Copy No. 706). Boundaries in the region extending from the γ to the ϵ phase of the Ag-Zn system were determined by X-ray analysis. The crystal parameters determined were accurate to at least 1 part in 5000. Results confirmed the existence of the boundaries in the generally accepted diagram, but they indicated that the positions of the boundaries need adjustment. The (γ)-$(\gamma+\delta)$ boundary requires adjustment in the direction of lower Ag content, by about 0.5% Ag by weight at the lower temperatures and by a progressively greater amount in the opposite direction at temperatures above 575° C. The $(\gamma+\delta)$-(δ) boundary needs to be displaced towards the Ag end of the diagram by about 4% in composition. The (δ)-$(\delta+\epsilon)$ and (δ)-$(\delta+\eta)$ boundaries should be more nearly parallel to the temperature axis. At the higher temperatures the (δ)-$(\delta+\eta)$ boundary moves toward the Ag end by about 4% in composition. The $(\delta+\epsilon)$-(ϵ) boundary is parallel to that of the accepted diagram but should be moved by about 1% toward the Ag end of the diagram. JLG (10)

2

Equilibrium Diagrams of Binary Alloys of Tin. E. S. Hedges & C. E. Homer. *Technical Publications of the International Tin Research and Development Council*, Series B, No. 2, Aug. 1935, 90 pages. Diagrams determined between 1903 and the present are shown for alloys of Sn with 34 other elements. When investigators disagree, the various diagrams are shown without indicating which is to be preferred. Thus there are 14 figures that show differences in the results of workers on the Sn-Cu system. The biblography includes references to all diagrams for a system whether they are reproduced or not. There is a discussion of the interpretation of equilibrium diagrams, the examples of different types being drawn from various alloys of Sn. It is very convenient to have this compilation in one set of covers. HWG (10)

3

X-rays in Theory and Experiment. Arthur H. Compton & Samuel K. Allison. D. von Nostrand, New York, 1935. Cloth, 6¼ x 9¼ inches, 828 pages. Price $7.50.

The most important task in reviewing a book of this calibre is to define clearly its scope, for the book is almost a necessity to those whose activities lie in its field, just as the first edition was in its day. It is a comprehensive treatise on the physics of X-rays. It covers the early classical theories, the more recent quantum theories, and the experimental data concerning the following phenomena: the emission of general radiation and of line spectra; the scattering of X-rays from independent electrons, groups of electrons, gases, liquids, and solids; the Compton effect and the analysis of the modified line; the reflection of X-rays from perfect and imperfect crystals, and the determination of the distribution of electrons in crystals from scattering and reflection data; the absorption, refraction, dispersion and polarization of X-rays; the diffraction of X-rays with ruled gratings and with the double crystal spectrometer, and precision wavelength determinations by these and other methods; the photoelectric effect. In the appendices, tables are given of absorption coefficients, wavelengths of emission lines and absorption edges, the electronic structures of the elements, the atomic structure factors, and terms for the X-ray spectra of numerous elements. There is no important theory of these phenomena that is not discussed, there is no fundamental equation that is not derived, unless the space required is prohibitive, and there is no crucial experiment that is not reported. Experimental technique is not described at length, however. While there is an excellent presentation of the relation between X-ray diffraction and the internal symmetry of crystals, there is no attempt to give more than a brief introduction to the subject of crystal structure and its determination. Consequently it does not duplicate the material to be found in books devoted to crystal structure, nor does it present metallurgical applications of X-rays. There is, for example, no mention of radiography; the details of tubes and transformers; the use of X-rays in the study of preferred orientations, internal stress, fatigue, diffusion, recovery, recrystallization, grain growth, solid solutions, intermetallic phases, structural analogies, allotropy, transition phases, or age hardening; or the diffraction of electrons and other particles. The mathematics in the book, of which there is a great deal (and beautifully printed), presupposes a knowledge of calculus, and in a few cases vector analysis. C. S. Barrett (10)—B—

4

Structure of Ni-Co Alloys (Sur la Structure des Alliages Nickel-Cobalt). Witold Broniewski & W. Pietrek. *Comptes Rendus*, Vol. 201, July 16, 1935, pages 206-208. Electrolytic Co and Ni were remelted in vacuo to make up the series of alloys from 0 to 100% Co which were then annealed 24 hours at 800° C. and cooled slowly over a 24 hour period. Curves show variations of composition with electric conductivity, Curie points, coefficient of dilatation, Brinell hardness, etc. No intermetallic compounds in the series could be identified. FHC (10)

5

On the Equilibrium Diagram of Nickel and Zinc (the 2nd report). Kanzi Tamaru & Atomi Osawa. *Kinzoku no Kenkyu*, Vol. 12, Mar. 1935, pages 131-147. In Japanese; *Science Reports Tohoku Imperial University*, Vol. 23, 1935, pages 794-815. In English. Results of the present investigation: (1) A peritectic reaction takes place at 517° between γ and melt forming ϵ phase. The range of the reaction lies between 13.5 and 0.5% Ni. (2) The volume of the alloys containing 10-11% Ni increases by about 3% with the formation of ϵ phase. (3) α-solid solution has a face-centered-cubic lattice. The parameter increases very rapidly up to 20% Zn, but then more slowly, reaching 3.592 A.U. at 38.9% Zn. (4) β-solid solution is a body-centered-tetragonal lattice. $a = 2.724$ A.U., $c = 3.168$ A.U., $c/a = 1.163$. γ solid solution has a body-centered-cubic lattice containing 52 atoms in a unit cell. $a = 8.927$ A.U. A compound $NiZn_3$ was considered to be γ-solid solution in the first report, but according to X-ray analysis it was found to be Ni_5Zn_{21}. (6) δ-solid solution has a face-centered-tetragonal lattice. $a = 3.867$ A.U., $c = 3.203$ A.U., $c/a = 0.8278$. (7) ϵ phase is a tetragonal lattice and contains 50 atoms in a unit cell. $a = 8.922$ A.U., $c = 9.254$ A.U., $c/a = 1.037$. This phase has the formula Ni_2Zn_{11} and contains 10.9% Ni. KT (10)

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6

Equilibrium Diagram of Mg-rich Mg-Al-Si Ternary System. Hachie Sawamoto. *Suiyokwai-Shi*, Vol. 8, Apr. 1935, pages 713-727. In Japanese. The equilibrium diagram of Mg-Al-Si system on the Mg side was determined by means of thermal and microscopic studies. The ternary-eutectic temperature was found to coincide with the eutectic temperature of the Mg-Al system. It exists at 437° C. and contains 32.7% Al, 67.3% Mg. HN (10)

7

The Solubility of Lead in Mercury. Herbert E. Thompson. *Journal of Physical Chemistry*, Vol. 39, May 1935, pages 655-664. A special solubility apparatus was designed and a special experimental technique developed for the efficient handling of the rapidly oxidized Pb amalgams. This type of apparatus and technique may be of use also in studies of other easily oxidized amalgams. About 70 determinations of the solubility of Pb in Hg were made in the temperature range 20°-70° C. with an average deviation of about 5 parts/1000 for the final runs. The experimental results are adequately represented by the following equation within the temperature range studied:

$$N_{Pb} = 0.5893 - 0.004115\ T + 0.000007354\ T^2.$$

The solubility of Pb in Hg drops from 4.33 at. % Pb at 70° C. to 1.476 at. % Pb at 20° C. EF (10)

8

Graphite Formation in Gray Iron (Graphitbildung im Grauguss). H. Nipper. *Giesserei*, Vol. 22, June 7, 1935, pages 280-287. Gray Fe consists of a metallic base in which graphite flakes are imbedded more or less regularly. The base substance is built up, according to temperature and heat treatment, of polycrystalline γ-Fe, pearlite in its various forms, ferrite, or of several of these constituents together. The size of the crystalline graphite flakes is about 100 A.U. The crystallographic conditions of graphite in gray Fe are illustrated by micrographs, the effects of under-cooling on the structure of hypo-, hyper-eutectic, and eutectic cast Fe alloys are discussed and suggestions for the treatment of the melt are made. Ha (10)

9

Investigations of Heat Changes During Metallic Transformations. III. Iron (Untersuchungen über die Wärmetönung bei metallischen Umwandlungen. III. Eisen). H. von Steinwehr & A. Schulze. *Physikalische Zeitschrift*, Vol. 36, June 15, 1935, pages 419-432. The contradictory previous investigations by various experimenters are summarized. An 18 kg. block of vacuum-melted electrolytic Fe of 99.97% purity (0.03% Mn and traces of Si) was utilized for determining the heat changes of the magnetic A_2 and allotropic A_3 transformation. The heat evolution of transformation, which according to the present investigation extends over the temperature range 710° to 790° C., yielded $Q = 4.8$ cal./g. (mean error $= \pm 0.2$ cal./g.) The heat change at the allotropic A_3 transformation was found to be $Q = 6.2$ cal./g. with a mean error of ± 0.08 cal./g. The characteristic difference between both kinds of transformation can be clearly recognized in their caloric behavior. The present experimental method could not be applied to the determination of the A_4 transformation owing to the rapid evaporation of Fe at the extreme temperatures involved. (See also abstract above). EF (10)

10

Distortion of Metal Crystals. C. F. Elam. Oxford University Press, New York, 1935. Cloth, 6¼ x 9½ inches, 182 pages. Price $5.00.

Mrs. Tipper's (C. F. Elam) book covers a wide range of subjects of interest to the physical metallurgist; so wide, in fact, that many of the subjects on which she touches are quite inadequately discussed. This will lead to some dissatisfaction on the part of those familiar with the literature in this field, who will also feel that parts of the book are loosely written. But for the metallurgist whose interest in these matters is general rather than specific it will be found to be interesting reading, and for those who wish to become more familiar with these aspects of metallurgy it will be found an excellent guide to the literature of crystal plasticity and related subjects. The author discusses the preparation and deformation of single crystals of metals and alloys, the deformation of polycrystalline metal, deformation under repeated stresses, fracture, the effect of time and temperature on these tests, the alteration of X-ray reflections, the relation between work done and energy absorbed, changes in physical properties accompanying deformation, plasticity, and finally a theoretical discussion. Her book is to be particularly commended for the large number of references to the literature, and is, in addition, well printed and contains many useful diagrams and interesting plates. While the book will not serve as a handbook for those engaged in research along these lines, the geometrical treatment of the deformation of crystals will be found to be pretty heavy reading by those unfamiliar with the subject, and the serious reader will want to make use of the references. The reviewer feels that much of the discussion of the phenomena described is not sufficiently critical, and some important aspects of the subject are ignored; for instance, nither the role of "lineage" structures nor of overstrain aging is considered as the cause of some of these phenomena. However, the author should not be overly criticized for omissions from a survey book of this type. It will be found a worth-while addition to a metallurgist's library. M. Gensamer (10)—B—

Principles of Phase Diagrams. J. S. Marsh. McGraw-Hill Book Company, New York, 1935. Cloth, 6 x 9¼ inches, 193 pages. Price $3.00.

The prime object of this, the fifth volume in the Alloys of Iron Research Monograph Series sponsored by the Engineering Foundation, is a presentation of a key to the interpretation and construction of ternary phase diagrams, a number of which have appeared in the earlier volumes of the series. In carrying out his task the writer has attempted to produce at once a brief and comprehensive presentation of his subject. This has led to a highly condensed, yet somewhat popular treatment of the thermodynamic principles bearing upon the powers and limitations of phase diagrams, followed by an even more condensed outline of the fundamental types of diagrams possible in systems of one, two, and three components. Of its six chapters the first two are devoted to the thermodynamic background, the third to phase diagrams of one and two component systems, the fourth and fifth to systems of three components, and the sixth largely to a practical example in the case of the iron-carbon-silicon system. Among the more interesting features of the book may be mentioned a series of discussions of common errors and misconceptions, a scheme of classifying transformations which reduces the number of types occurring in the binary systems to four, and the introduction of a new system of nomenclature for the points, lines, and spaces in phase diagrams. The simplified plan of classifying transformations carries with it a number of obvious advantages, but the abbreviation of the subject matter effected thereby and the near absence of practical illustration makes necessary an uncommonly close attention and extensive use of the imagination on the part of the reader. While it is doubtless true that a logical and complete system of nomenclature is a convenience, if not a necessity, in any field of science and that the earlier such a system is established the more useful it may become, it may also be true that a too cumbersome nomenclature may impede the development of a subject by lending to its obscurity. In the present instance, for example, it seems improbable that the interested public will readily exchanage the comparatively euphonious term "eutectic line" for the more cumbersome proposed "bin. 2 tricygic line." To the author's credit it should be observed, however, that the book has been so written that the reader may, if he chooses, disregard most of the new terms without fear of misunderstanding. These objections are minor. The reviewer knows of no other work in the English language which treats so well the subject of ternary phase diagrams. Indeed, the handling of this material compares very favorably with that of G. Masing's recent work in German entitled "Ternäre Systeme." The descriptive matter, being more condensed, is somewhat more difficult to follow, but the present book excels its German counterpart in the completeness of its treatment. The fact that this volume does not cover exhaustively, or even adequately, as many of the branches of the subject of phase rule application as one could desire serves only to emphasize the need for more books in this field. F. N. Rhines (10)—B—

Diffraction of Electrons by Outside Films on Molten Metals. J. A. Darbyshire & E. R. Cooper. *Transactions Faraday Society*, Vol. 30, Nov. 1934, pages 1038-1048. Contains bibliography. The study was made of CdO, BiO, MgO, Al_2O_3 by means of electron diffraction. The electron beam was obtained from a hot-cathode discharge tube and focused by means of a solenoid of 2,000 ampere turns. The patterns observed for Cd, Mg and Al oxide corresponded quite well with those to be expected. Definite discrepancies occur between theoretical and observed intensities. For CdO, the 220 is the strongest observed ring, whereas 200 should be the strongest and there was one extra ring having d/n equal to 1.735. No extra rings were observed for MgO but the observed intensities differ from theoretical. The oxide of Al was found to be the face-centered-cubic modification known as γ Al_2O_3. The BiO pattern obtained corresponded to a centered-tetragonal lattice of axial ratio 1.04. The experimental results have indicated that there are still many points about the process of electron diffraction which are not yet thoroughly understood. PRK (10)

Two-dimensional Super Structures (Zweidimensionale Überstrukturen). Fritz Laves. *Zeitschrift für Kristallographie*, Abt. A, Vol. 90, Mar. 1935, pages 279-282. Reports on peculiar superstructures observed on Ni_2As_2. The phenomenon of 2-dimensional superstructures is discussed by means of 6 X-ray photographs. The fact that superstructures need not be only 3-dimensional but may also be 2-dimensional appears to the author to be of some significance for the investigation of thermal treatments of alloys. EF (10)

X-ray Study of Residual Stresses in Metals. Y. P. Kourdinovski. *Vestnik Metallopromishlennosti*, Vol. 14, Dec. 1934, pages 46-54. In Russian. The amount of residual deformation was determined by precision measurement of asterism produced on Laue photographs by means of a Zeiss microphotometer. (10)

Oriented Intergrowth and Overgrowth in Relation to Modification of Crystal Habit by Adsorption. Clifford Frondel. *American Journal of Science*, Vol. 30, July 1935, pages 51-56. Factors determining the absorbing plane in habit modification are held to be similar to those governing the appearance of the separating phase in oriented overgrowths and in oriented intergrowths. Oriented intergrowths from solid solution frequently occur in alloys, as Desch has shown. Control of adsorption is primarily by similarity along particular lattice planes of the new phase; the foundation is reciprocal along similar planes for the separating crystal in overgrowths and intergrowths and as the favored plane in modification of habit. Overall similarity of structure leads to crystallization equally in 3 dimensions as in the dendrites or polyhedra for certain Zn alloys. WB (10)

Investigations of Heat Changes During Metallic Transformations. II. (Untersuchungen über die Wärmetönung bei metallischen Umwandlungen. II.) H. von Steinwehr & A. Schulze. *Physikalische Zeitschrift*, Vol. 36, May 1, 1935, pages 307-311. Continuing previous research (I. β-brass, *Physikalische Zeitschrift*, Vol. 35, May 15, 1934, pages 385-397), the heat change of the $\alpha \longrightarrow \beta$ transformation was determined in a 20 kg. Co block. $Q\ \alpha \longrightarrow \beta = 0.1$ cal./g. with a mean error of $\pm$ 0.03 cal./g. The heat change of the magnetic transformation was found to be: $Q_{magn.} = 1.2$ cal./g. with a mean error of $\pm$ 0.07 cal./g. The transformation temperature range of the allotropic change extends from 380° to 420° C. and that of the magnetic transformation from 1070° to 1125° C. EF (10)

Nucleus Formation During Recrystallization. I. (Über die Keimbildung bei der Rekristallisation. I.) M. Kornfeld. *Physikalische Zeitschrift der Sowjet Union*, Vol. 7, No. 4, 1935, pages 432-441. In German. The conceptions "velocity of nucleus formation, beginning of recrystallisation and recrystallization ability" are precisely defined and experimental data on cold-rolled Al are presented to illustrate the definitions. Diagrams show the interrelations among nucleus formation speed, linear crystal growth (of newly formed grains) and amount of cold work. Postulates that the incubation period is inversely proportional to the velocity of linear crystal growth. EF (10)

Reactivity and Catalytic Activity of Solids in Transitional States (Über Reaktionsfähigkeit und katalytische Aktivität der festen Materie in Übergangszuständen). J. Arvid Hedvall. *Svensk Kemisk Tidskrift*, Vol. 47, June 1935, pages 161-188. In German. Paper before the Joint Meeting of Kemistsamfundet and Kemiska Sällskapet, Stockholm, points out many phenomena observed in mineralogical, metallurgical, metallographic and (heterogeneous) catalytic fields which indicate that materials display a much greater activity in the solid state than has been generally assumed. Many problems of metallurgical significance are discussed as for instance diffusion in crystals, phase changes, reactions in the solid state, (η and ϵ- phase of Cu-Sn system with CuO) reduction of Fe_2O_3, dissociation of Fe_2S, dissolution of Cu and Bi in HNO_3, mosaic structure in metals, reaction of metal oxides with SiO_2, ferromagnetic changes (Ni and Ni-Cu). 42 references. EF (10)

Grain Size and Steel Quality (Kornstorlek och Stalkvalitet). Einar Öhman. *Jernkontorets Annaler*, Vol. 119, Apr. 1935, pages 143-174. Résumé of work on controlled C steels based largely on American research and practice. HCD (10)

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The Change from Metallic to Heteropolar Bonding (Der Übergang von metallischer zu heteropolar Bindung). U. DEHLINGER. *Zeitschrift für Elektrochemie*, Vol. 41, June 1935, pages 344-346. According to the work of E. Zintl (*Zeitschrift für Physikalische Chemie*, Vol. 21, 1933, page 138) a number of Mg alloys were shown to form compounds with non-metallic type lattice (as in fluorspar, etc.) when there were present components capable of forming anions with a maximum valence of 4, otherwise the typical metallic lattice resulted. In the case of the metallic compound $AuAl_2$ (C. D. West & A. W. Peterson, *Zeitschrift für Krystallographie*, Vol. 88, 1934, page 93) which has a fluorspar structure the author believes the above rule applicable because he regards the complex Al_2 rather than the single Al atom as being effectively anionic in that the complex lacks only 2 electrons for a complete shell. In the $Mg_{17}Al_{12}$ and $CuAl_2$ structure this complex Al_2 has definite geometric form and the author shows that in these structures a partially heteropolar loading distribution is the case. Analogies are drawn between the behaviour of the Mn atom and complex with the Mg atom and Al complex and the previous work of the author (U. Dehlinger, *Zeitschrift für Elektrochemie*, Vol. 41, 1935, page 20; *Metals & Alloys*, Vol. 6, May 1935, page MA 206L/9) completed in a table of the present article. This table gives the mutual relations of Mg, Zn, Al, Sn as regards miscibility and formation of metallic or heteropolar compounds. WB (10)

The Occlusion and Diffusion of Hydrogen in Metals. A Metallographic Study of Palladium-Hydrogen. DONALD P. SMITH & G. J. DERGE. *Transactions Electrochemical Society*, Vol. 66, 1934, pages 253-270. Metallographic evidence is presented showing that the principal entry of H into Pd is along certain rather widely spaced members of the octahedral and dodecahedral sets of planes which intersect the surface, and that the H spreads from the octahedral into other dodecahedral planes. From detailed discussion of the facts it is deduced that the ready diffusion takes place in minute fissures which are not improbably the result of octahedral cleavage. The susceptibility of the metal to attack by etching agents is shown to vary in parallel with the avidity with which it takes up H from the gas phase and hence also to be related, in all probability, to the presence of the fissures. It is concluded that occlusion by the intra-granular fissures, rather than by grain faces, is of primary importance. (10)

Crystal Growth and Nucleus Formation (Kristallwachstum und Kristallkeimbildung). I. N. STRANSKI & R. KAISCHEW. *Physikalische Zeitschrift*, Vol. 36, June 1, 1935, pages 393-403. The evolution of the theory of nucleus formation and crystal growth (Gibbs, Volmer & collaborators, Kossel & Stranski) is reviewed. It is pointed out that there are no contradictions between Volmer's theory and Kossel & Stranski's derivations although both approach the problem from different directions. As a crystal model, the cubic lattice is discussed. The Thompson-Gibbs equation is modified and it is derived, that a certain vapor pressure corresponds to each minute crystal particle (equilibrium state) but not vice versa. Since a crystal grows only by a whole number of lattice planes, its vapor pressure can only assume definite values which, however, fall upon the curve expressing the Thompson-Gibbs equation. The formation of the 2- and 3-dimensional crystal nuclei is dealt with mathematically, and the equilibrium form of crystals is discussed at length. The mechanism of crystal growth and solution is extended to "sub-crystal sizes," i.e. to nucleus formation and linear crystallisation speed. It is hinted that the applied methods should also be useful in the treatment and interpretation of phenomena connected with recrystallisation of solids. (See also *Metals & Alloys*, Vol. 5, Dec. 1934, page MA 579 L-5; Vol. 6, Feb. 1935, page MA L-[illegible]) EF (10)

Two Intermetallic Compounds of Beryllium with Iron (Über zwei intermetallische Verbindungen des Berylliums mit Eisen). L. MISCH. *Naturwissenschaften*, Vol. 23, May 3, 1935, pages 287-288. A compound $FeBe_2$ whose structure is hexagonal and similar to that of $MgZn_2$, was found in the Fe-Be system. There are 12 atoms per unit cell. The lattice constants are $a = 4.212$ A.U. and $c = 6.834$ A.U. The density is 4.65 g./cc. The parameters of the lattice point positions are $u = 0.833$ and $v = 0.063$. This phase has a ferromagnetic transformation at 521°-524° C. The direction of strongest magnetism lies in the hexagonal base plane. Another compound, $FeBe_8$, was found which is not ferromagnetic at ordinary temperatures, but is attracted by an electromagnet at liquid air temperatures. The structure is face-centered cubic and similar to $MgCu_2$, with 24 atoms per unit cell. The 8 point positions of the Mg atoms are occupied statistically by 4 Fe and 4 Be atoms. The lattice constant is 5.878 A.U. A complete description of these compounds is to be published shortly. EF + HAS (10)

Graphitization of Iron-carbon Alloys Considered by Change of Energy. KEIZO IWASE & KOKITI SANO. *Tetsu-to-Hagane*, Vol. 21, Apr. 25, 1935, pages 220-223. In Japanese. Change of free energy upon the reaction $3Fe + C = Fe_3C$ may be calculated from the heat of formation of Fe_3C at 25°, specific heats of Fe_3C, graphite and Fe (α, β and γ) at 0°-1100°, and heats of transformation of A_0, A_2 and A_3 in Fe-C alloys or from the equilibrium constants of the reactions, $3Fe + 2CO = Fe_3C + CO_2$ and $2CO = C + CO_2$ at higher temperatures. Using these thermochemical values which were determined by many investigators, the change of free energy has been calculated. The calculation has been made in 2 ways by thermodynamic relations: (1) $\Delta F^\circ = -RT\ln K_p$ and (2) $\Delta Cp = (d\Delta H/\Delta T)_p$ and $-\Delta H/T^2 = [d(\Delta F/T)dT_p$. In carrying out circulation (2), proper correction has been made, as the γ Fe dissolves C and forms austenite. This has been done by applying the Nernst formula of dilution, *i.e.*, $\Delta F^\circ = -RT\ln N_1/N_2$. The results of these 2 ways of calculation showed good agreement, i.e., ΔF° in the above formulas becomes 0 at 960° and 964° respectively, being positive below these temperatures. This means that the Fe_3C is unstable and should decompose into austenite and graphite below these temperatures, while above these temperatures its decomposition cannot take place, as it is more stable than the equivalent mixture of austenite and graphite. Hence it may be concluded that Fe_3C is metastable at lower temperatures, but at higher temperatures graphite is metastable. TS (10)

Allotropic $\alpha \longrightarrow \gamma$ Iron Transformation (Allotrope $\alpha \longrightarrow \gamma$ omzetting in zuiver ijzer). *Polytechnisch Weekblad*, Vol. 29, Mar. 14, 1935, page 175. A table shows the A_3 transformations in Fe of 10 different origins. WH (10)

The Metallic State. *Nature*, Vol. 136, July 20, 1935, page 115. A summary of a conference of physicists on "The Metallic State" at University of Bristol, England. Discussions concerned X-ray emission and absorption, superlattices, conductivity of bismuth crystals, recent discoveries in magnetism. CSB (10)

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11. PROPERTIES OF METALS AND ALLOYS

Conversion Data, Melting Points and Temperature Colors Shown on Chart. *Steel*, Vol. 96, Apr. 8, 1935, page 36. Shows m.p. of metals and alloys of practical importance. MS (11)

Surface Tension of Molten Metals and Alloys. V. Surface Tension of Fe-C Alloys, Hg_5Tl_2, $NaHg_2$, Its Variation with Time with Thallium and Surface Tension of Slags. After the Investigation of B. Schmidt & F. Pelka (Die Oberflächenspannung geschmolzener Metalle und Legierungen. V. Die Oberflächenspannung von Fe-C-Legierungen, Hg_5Tl_2, $NaHg_2$, Ihre zeitliche Veränderung bei Thallium und die Oberflächenspannung von Schlacken. Nach Versuchen von B. Schmidt und F. Pelka). F. Sauerwald. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 223, May 23, 1935, pages 84-90. Tests on the alloys were made with a pressure-bubble method described by Kenyo Hondo, in an atmosphere of 50-50 H_2 and A. Quartz capillary tube was used for Fe-C alloys and dipped into metal bath. Before and after the tests the tube was calibrated with Hg. The average values with a deviation of $\pm$ 5% are:

%C	Temp. °C.	Surface Tension—dynes/cm.
3.9	1300	1150
	1400	1300
	1420	1340
2.2	1420	1500

A constantly positive temperature coefficient is indicated. The C content is an arithmetical average of C before and after test since the protecting atmosphere gave rise to a slight decarburization. Part 2 discusses tests made on $NaHg_2$ and Hg_5Tl_2 by the same method using a quartz capillary. Tabulated data are given. Part 3 discusses the variation of surface tension of Tl due to gas content. A new apparatus proposed by B. Schmidt was used in which the height of the drops of molten Tl could be measured in a vacuum. After several days of degassing the melt in vacuum, consistent readings could be obtained. Data are tabulated. Part 4 reports the tests made on several slags by the same method but with a Pt capillary. The tubes were calibrated with molten Li_2SiO_3 for which the surface tension was known. Three slags were studied which E. Diepschlag & M. Michalke (*Giesserei*, 1934, page 493) and E. Diepschlag & L. Treuheit (*Giesserei*, Vol. 18, 1931, page 705) have reported to be a metallurgical problem in that they influence the Fe structure and the size of the graphite in gray iron casting. The composition of the slags and the surface tension are given. An attempt is made to explain the effects on the physical properties of the graphite. WB (11)

Are Metals Permeable by Oil? A. H. Gill. *Mechanical Engineering*, Vol. 57, July 1935, pages 413-414. Experiments made to solve the question whether metals can absorb oil showed that leaded bronze will absorb about 0.3% oil by weight and that it penetrates at least 0.375". Mild steel did not absorb oil, and babbitt metal behaves similarly to bronze. 5 references. Ha (11)

Number of Electrons Contributing to Paramagnetism of Nickel (Nombre des Électrons qui Contribuent au Paramagnétisme du Nickel). Louis Néel. *Comptes Rendus*, Vol. 201, July 8, 1935, pages 135-136. Author proves by means of the Curie constant that the electrons in Ni which contribute to paramagnetism are identical to those concerned with ferromagnetism. FHC (11)

Electric Resistance Metals (Ueber elektrische Widerstandsmetalle). Alfred Schulze. *Giesserei*, Vol. 22, June 21, 1935, pages 312-314. A review of compositions of materials used in resistors and as heating elements in furnaces, and their properties. The highest service temperatures can at present be obtained with alloys of 65% Fe, 30% Cr, 5% Al and of Fe-Cr-Al-Co which will stand 1350° C. Ha (11)

Alloys—Old and New. Sir H. C. H. Carpenter. *Engineer*, Vol. 159, May 10, 1935, pages 492-494; *Engineering*, Vol. 139, May 10, 1935, pages 497-498. From the Presidential address delivered before the Iron & Steel Institute, May 1935. LFM (11)

11a. Non-Ferrous

A. J. PHILLIPS, SECTION EDITOR

Thermal and Electrical Conductivities of Copper Alloys. Cyril Stanley Smith & Earl W. Palmer. *Metals Technology*, Sept. 1935, *American Institute Mining & Metallurgical Engineers Technical Publication* No. 648, 21 pages. Electric and thermal conductivities of Cu-rich alloys of Si, Al, Mn, and Ni and a large number of ternary or more complex alloys are reported. Both conductivities are given for 20° and 200° C. As the amount of added element increases the Lorenz ratio $\left(\frac{K}{\lambda T}\right)$ increases, at first rapidly and then more slowly. The thermal conductivity of alloys increases with temperature, although that of pure Cu decreases. The ratio between electric and thermal conductivity varies considerably, but it is shown that all results at both temperatures for all Cu alloys lie on a single curve when the thermal conductivity is plotted against the product of electric conductivity and absolute temperature. This curve is almost a straight line and intersects the thermal conductivity axis at a small but definite value. The results of all alloys measured lie much closer to this curve than any curve of constant Lorenz ratio. A table is given for the approximate conversion of thermal and electric conductivity of Cu-base alloys at 20° C. 13 references. JLG (11a)

Calcium: Its Metallurgy and Technology. C. L. Mantell & Charles Hardy. *Transactions Electrochemical Society*, Vol. 66, 1934, pages 63-83. See *Metals & Alloys*, Vol. 6, May 1935, page MA 206R/10. (11a)

Properties of Distilled Calcium (Propriétés du calcium obtenue par sublimation). Paul Bastien. *Revue de Metallurgie*, Vol. 32, Mar. 1935, pages 120-136. Impure Ca having the composition: 86.7% Ca, 9.1 CaO, 2.7 $CaCl_2$, 0.35 Si, 0.88 Fe, 0.2 Al was distilled in vacuum and remelted using the method of Herenguel & Chaudron, *Comptes Rendus*, Vol. 195, page 1272. The metal produced was sound and analyzed 99.3 Ca, 0.02 Fe, trace Cl, 0.14 Si. Two heat evolutions were observed by means of a differential Pt-Pt:Rh thermocouple, at 435° and at 270° C. the latter being about ⅓ as great as the former. With a more delicate method the transformation points were found to be at 240° and 430° C. Heating specimens of distilled Ca in evacuated tubes for 24 hours and quenching them in H_2O showed the average hardness under the lower critical as 14 on Pomey and Voulet scale, above it as 17, and above the upper critical as 27. α phase is stable under 260° C., β between 260° and 440° C. and γ above 440° C. The dilatation curves obtained in air on impure Ca indicated 2 additional transformation points apparently due to the action of atmospheric N on the metal. Distilled Ca on heating in air gave curves similar to those obtained in argon. Coefficient of dilatation for α Ca was 25.2 x 10^{-6}, for β 29.9 x 10^{-6}, for γ 29.9 x 10^{-6} as determined in a Chevenard dilatometer. Specific gravity at 20° C. was 1.542 $\pm$ 0.0005. Ductility of Ca is greatly affected by impurities. Distilled Ca had 53% elongation, 98.5% Ca had 30.5 while the impure metal of the analysis given above did not have any elongation. Sublimed Ca had 4.4 kg./mm.² tensile strength. With loading speed of 4 mm./min. distilled Ca is more ductile than Al (99.6%) and less ductile than Pb, but it has a greater elongation than either of them. Elongation of Ca at the fracture is considerably greater than that of Al and Pb. Modulus of elasticity of distilled Ca was between 2250 and 2750 kg./mm.² Creep testing at room temperature using the range of loading 0.015 to 1.200 kg./mm.² showed a maximum tensile load without creep at 0.4 kg./mm.² Cylinders of distilled Ca crushed to 50% of their original height at different temperatures showed a complete recrystallization during deformations at and above 300° C. The pressure required for this deformation decreases with the temperature and has a sharp break at 440° C. γ Ca plastically deforms under very small loads. Cylinders did not show any surface cracking during the deformation. Wires of distilled Ca were extruded readily at 420-460° C. These wires had 5.7 kg./mm.² tensile strength, 3.9 kg./mm.² elastic limit and 61% elongation. A 1% solution of HCl in 95% alcohol dissolves in 10 hours 116 mg./cm.² of distilled Ca and 147 mg./cm.² of the impure metal. A series of corrosion experiments indicated that H_2SO_4 either concentrated or diluted to 9% attacks the metal but slightly, but with greater dilutions corrosive attack increases. HCl attacks the metal rapidly having a sharp drop in the dissolving power at 0.5% HCl. Fuming HNO_3 acts but slowly, but the attack increases when small amounts of H_2O are present. NaOH solutions from 36° Be down to 10% corrode distilled Ca very slowly, but with further dilution the attack increases. See also *Metals & Alloys*, Vol. 6, Feb. 1935, page MA 72L/8. JDG (11a)

Properties and Uses of Lead-Base Bearing Metals. E. T. Richards. *Metal Industry*, London, Vol. 45, Dec. 7, 1934, pages 533-535. The general opinion that the best white bearing metals were those with a Sn base was, by necessity, considerably changed by the World War. For the Allies, Sn was too expensive and for the Central Powers, it was practically non-existent. By necessity then, interested industries were compelled to investigate alloys containing, in addition to Pb, a minimum of Sn. New alloys were not perfected but the major advantages of the investigations were in the improvement of methods of production and of handling the Pb-rich alloys of low Sn content. It was found that the chief disadvantages that had been attributed to the Pb-base alloys were really due to the haphazard methods used in their production and use. Binary Pb-Sb alloys had been successfully used for slow running, heavily loaded bearings free from shock or vibration. The best alloys of this type contained 13% Sb which had a maximum hardness and minimum brittleness. The only method to obtain increased hardness from higher contents of Sb without increasing the brittleness was found to be by addition of small percentages of Sn. A standard type of alloy brought out by general practice now contains in addition to Pb, 15% Sb, 5% Sn, and 0-1.5% Cu. This is now used in England, U. S. A., and Germany. It is suggested that the Sb should not be over 18%, even if the Sn is above 10%, as the improved hardness obtained by the Sb is accompanied by increased brittleness and increased sensibilities to shock and vibration. This alloy is satisfactory for medium speeds and loads, low speed and high loads or high speed and low loads. Among the advantages claimed for the Pb-rich bearings metals over the Sn-rich is that the former have a lower degree of sensibility toward small temperature changes. However, the Sn-rich bearings, due to their higher coefficient of thermal conductivity, are more satisfactory where sudden increases in heat, that must be rapidly conducted away, are encountered. The influence of pouring temperature on the properties of these alloys is discussed. The influence of preheating the molds is also considered. The chief factors deemed to determine the usefulness of these alloys as bearing metals are: (1) maximum percentage of hard constituents, (2) minimum size of constituents, and (3) proper and uniform distribution of the hard constituents within the soft and plastic, but strong matrix. The need of care in pouring is emphasized as well as precautions to be observed during cooling to room temperature. A list of Pb-rich white bearing metals being used in England, U. S. A. and Germany is appended. HBG (11a)

Lithium. Hans Osborg. *Transactions Electrochemical Society*, Vol. 66, 1934, pages 91-105; *Metal Industry*, London, Vol. 45, Dec. 21, 1934, pages 585-587; Dec. 28, 1934, pages 617-618. Li metal and alloys are now being produced on a large commercial scale. The physical and chemical properties of the metal are briefly reviewed and compared with those of the other members of all alkali metal group. Of the compounds, LiH and Li_3N are of special interest. Important technical applications include the treatment of molten Cu and bronzes with Li-Ca (50: 50, 30: 70) alloy. An exceptionally pure and high conductivity Cu is obtained. The Li-Ca alloy added to molten cast iron, C steel and stainless irons and steels greatly improves their physical properties. Li added to Mg increases its corrosion resistance and tensile strength. Less than 0.5% Li added to Al-Zn alloys develops mechanical properties similar to those of mild steel. HBG (11a)

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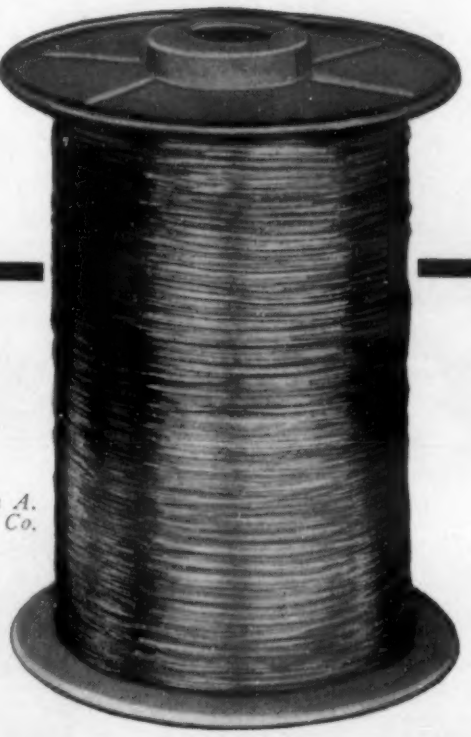

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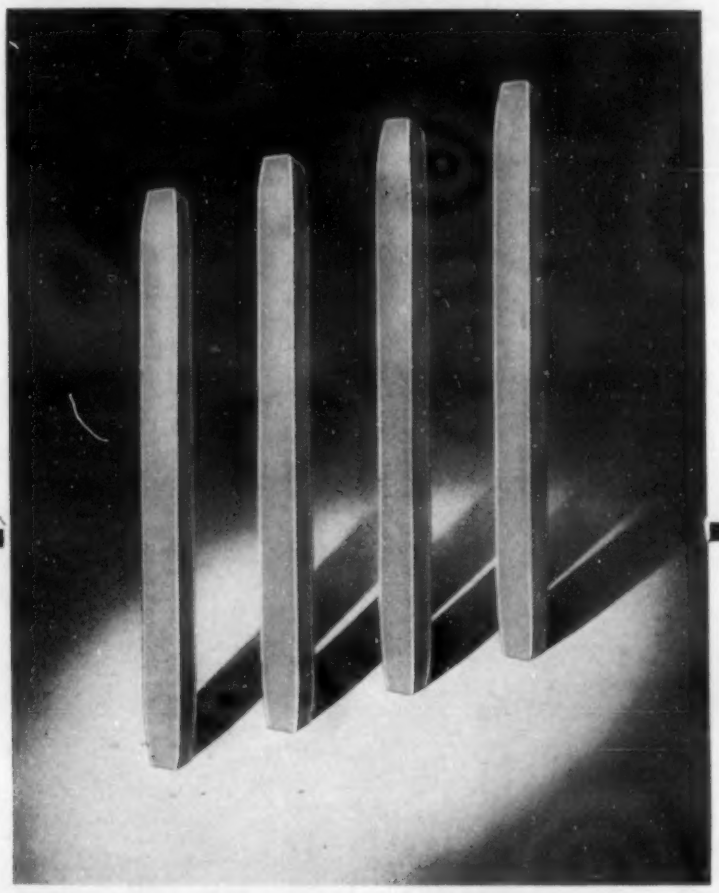

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Lead and Its Alloys. Comprehensive Presentation of Its Properties (Blei und seine Legierungen. Zusammenfassende Darstellung der Eigenschaften). ARTHUR BURKHARDT. *Metallwirtschaft,* Vol. 14, June 7, 1935, pages 445-449; July 5, 1935, pages 525-531; July 26, 1935, pages 581-587; Aug. 9, 1935, pages 625-630. A brief survey of the entire field of the properties of Pb and its important alloys with 206 references to the literature. Under pure Pb the atomic, crystallographic, mechanical, thermal, electrical, magnetic and optical properties, gas solubility, electro-chemical properties, resistance to corrosion, toxicity, melting, casting, working, and heat treatment are covered. The effects of impurities and alloy additions on the mechanical and technological properties, and constitutional diagrams of binary and ternary alloys are given. Under commercial uses bearing metals, cable coverings, type metals, storage battery plates, and solders are discussed. CEM (11a)

Vanadium. B. D. SAKLATWALLA. *Transactions Electrochemical Society,* Vol. 66, 1934, pages 33-38; *Engineer,* Vol. 158, Oct. 12, 1934, pages 369-370. Only the more recent developments of V have been taken into consideration, without attempting to survey the old voluminous literature. Some of the newer theories evolved as to the formation of the V ore deposits, and as to the metallurgical effects of V have been discussed, especially as this forms probably the first published record of them. The fundamental properties of the V atom as such have been discussed, as it is considered that they are different from those of any other atom and responsible for some of the important technical effects. (11a)

11b. Ferrous

V. V. KENDALL, SECTION EDITOR

Electric Furnace Cast Iron—A New Engineering Material. A. E. RHOADS. *Iron & Steel of Canada,* Vol. 18, Mar.-Apr. 1935, pages 19-25. The modern trend of cast Fe production is to produce the type of cast Fe with properties suited to requirements in a given case, and the advantage which the electric furnace offers in obtaining this end are discussed. According to service requirements, the various types are classified as pressure irons which require extreme density of grain structure; high strength iron, a low C iron properly superheated or alloyed; heat or corrosion resistant irons obtained by special composition or microstructure. Methods of obtaining the properties by superheating, heat treatment, cooling rate and use of alloys are discussed and compositions of cast irons for different strengths are given. Ha (11b)

New Alloys for Magnets. ARTHUR B. EVEREST. *Metal Treatment,* Vol. 1, Spring 1935, pages 43-47. An historical discussion of magnet steels with particular attention to Mishima's MK Ni-Al magnet steel (25% Ni-12% Al) and the new Honda Co-Ni-Ti magnet steel (15-36% Co, 10-25% Ni, 8-25% Ti). Typical values of remanence and coercive force are as follows:

Material	Remanence	Coercive Force	Br x Hc	BH max.
1% C steel	9,000	55	500,000	200,000
6% W steel	11,000	70	770,000	300,000
3% Cr steel	9,000	65	600,000	250,000
15% Co-10% Cr steel	9,000	110	1,000,000	750,000
36% Co steel	11,000	300	3,300,000	1,500,000
Ni-Al steel (A)	6,000	600	3,600,000	1,300,000
Ni-Al steel (B)	8,000	510	4,200,000	1,750,000
New Honda steel	7,000	840	6,000,000	

JCC (11b)

Brittleness of Soft Casting Steel as Consequence of Certain Heat Treatments (De la Fragilité des Aciers doux de Moulage à la Suite de certain Traitements thermiques). J. GOUTTIER. *Revue de Fonderie Moderne,* Vol. 29, May 10, 1935, pages 149-150. The occurrence of brittleness in soft steels to which attention has been called by Lea and Arnold, is discussed. It occurs in 2 forms: (1) progressively, by aging at atmospheric temperature after rapid cooling from temperatures between 550° and 750° C. and (2) instantaneously, by quenching from temperatures around 750° C. Both forms can occur simultaneously so that brittleness becomes excessive. The results of investigations of the course of brittleness with time are described for 4 steels. Ha (11b)

New Development in Electrical Strip Steels Characterized by Fine Grain Structures Approaching the Properties of a Single Crystal. N. P. Goss. *Transactions American Society for Metals,* Vol. 23, June 1935, pages 511-544. Paper read and discussed at A.S.M. Convention, 1934. Previously abstracted from Preprint 30. See *Metals & Alloys,* Vol. 5, Nov. 1934, page MA 536. WLC (11b)

New High Speed Steel, Molybdenum with Tungsten. FRANK GARRATT. *Metal Progress,* Vol. 27, June 1935, pages 38-43. A high speed steel of C 0.76%, Mn and Si 0.30%, W 1.60%, Mo 7.90%, Cr 3.85% and V 1.10% of cutting properties comparable with conventional 18-4-1, W-Cr-V steel is described. The new steel is quenched from 2200° F. and drawn at 1000° F. and gives the same hardness with greater torsional impact resistance than 18-4-1 steel. Modified compositions are briefly discussed but they bear the same relation to the base composition given as modified 18-4-1 bears to that base composition. WLC (11b)

Notes on Roll Failures with Reference to Chilled Iron Cast Rolls Containing Chromium and Molybdenum. J. SELWYN CASWELL. *Proceedings, Institution of Mechanical Engineers,* Vol. 128, Nov.-Dec. 1934, pages 459-467. Some remarkable fractures of Cr-Mo rolls were investigated and compared with the fractures usually associated with ordinary chilled iron rolls. The causes of failure had apparently to be traced (1) to low strength of the Fe due to an excess of Cr, (2) to defective design of the roll wobbler, and (3) to the thermal stresses set up in the rolls during service. It is shown how incorrect molding of the roll might set up internal stresses during cooling which later leads to fracture. It is suggested that straight C rolls, properly used, may give long and high-quality service without resorting to higher priced Cr-Mo rolls. The Cr content in the 2 rolls investigated was 0.69 and 0.69-0.96 respectively with little or no Mo and 0.20-0.34% respectively. Ha (11b)

Composition of Common Cast Iron for Boilers (Studio sulla composizione della ghisa comuna caldaie). G. SIROVICH & G. VANZETTI. *La Metallurgia Italiana,* Vol. 27, Mar. 1935, pages 171-187. See *Metals & Alloys,* Vol. 6, June 1935, page MA 249R/1. AWC (11b)

Influence of Free Ferrite on Impact Strength. N. S. ZVEREV. *Vestnik Metallopromishlennosti,* Vol. 14, Dec. 1934, pages 98-102. In Russian. Low impact strength observed in processing parts made of 0.34-0.39% C, 0.33-0.48% Mn, 0.21-0.34% Si and 0.42-1.12% Cr steel was due to presence of free ferrite either not brought into solution before quenching or quenched too slowly for retaining it in solution. (11b)

Copper Steels. ERNEST E. THUM. *Metal Progress,* Vol. 28, June 1935, page 4. Discusses the unfounded prejudice against Cu in steel and calls attention to the occurrence of this element in high grade steels for many years. WLC (11b)

Influence of Titanium on Allotropic Transformation of Iron. V. N. SVECHNIKOV & V. N. GRIDNEV. *Domez,* 1935, No. 2, pages 41-43. In Russian. On the basis of 3 heats containing 0.17, 0.36 and 0.59% Ti without specifying the contents of other elements the equilibrium diagram and the properties of the alloys are discussed. (11b)

The Effect of Copper in Grey and Malleable Cast Iron. A. J. N. SMITH. *Bulletin British Cast Iron Research Association,* Vol. 4, Apr. 1935, Bureau Report 134, pages 124-127. A review of existing information on the subject. Brief discussion of the effect of Cu on casting properties, structure and graphitization. Investigations in progress at the B.C.I.R.A. laboratories indicate that effect of Cu in quantities up to between 2 and 5% is to graphitize the casting, above this amount the Cu tends to harden the Fe. The exact % at which Cu effects the change depends largely upon the composition of the Fe base. Much of the apparent confusion in the literature is due to the fact that many of the researchers have investigated the effect of Cu up to only 2 or 3%. In most cases the effect of Cu on form, size and distribution of graphite is uncertain or very slight. Discussion of some evidence that Cu has a slightly refining action on the graphite and the liquid and solid solubility of Cu in cast Fe, influence of Cu on mechanical properties and corrosion resistance. Discussion of effect of Cu in malleable Fe, the article being a running commentary on the various phases of the subject. Bibliography. WB (11b)

Molybdenum Exerts Three Principal Effects in Corrosion Resisting Steels. C. M. LOEB, JR. *Steel,* Vol. 96, June 24, 1935, page 35. Mo effects control of structure as in 18-8 Cr-Ni stainless steel, where it prevents or hinders carbide precipitation at grain boundaries. Such precipitation which does occur is usually evenly distributed within the grains. Addition of 3-20% Mo to Fe-Cr, Fe-Cr-Ni, or Fe-Ni alloys greatly improves their resistance to exceptionally corrosive conditions. Mo intensifies effects of other alloying elements in Fe or steel. MS (11b)

Aluminum in Cast Iron (Influence des Additions d'Aluminium sur les Propriétés des Fontes Ordinaires). MARCEL PLOYÉ. *La Fonte,* Apr.-May-June 1935, pages 601-613. The first part of a study of the alloys of Al in ordinary cast irons. 3 grades of cast Fe were used as base for alloys. Al content varied from 0 to 18%. Total C content decreased with increasing Al. Up to 2% Al, the combined C decreased, especially marked in the case of one cast Fe having a heavy chill believed due to oxidation. From 8 to 12% Al, the combined C increased rapidly and practically all C was combined at 12% Al content. Over 12% Al, graphitic C increased. Chill tests gave results checking with, but more pronounced than, changes in combined C. Complex carbides and solid solution of Al in Fe were apparent in high Al alloys. In general, hardness increased slowly up to 8% Al, increased rapidly from 8 to 12% Al and then decreased slightly up to 18% Al. Transverse strength increased slightly with very small additions of Al, then decreased up to about 12% Al content, and increased slightly again between 12 and 18% Al. Over 10% Al content, the alloy did not increase in length during dilatometric measurements. The 3 different base irons gave slightly different results, but the general trends were similar. WHS (11b)

Alloy Sheet Steel (Copper-Nickel-Molybdenum). HOWARD L. MILLER. *Metal Progress,* Vol. 28, June 1935, pages 28-31, 70. Describes the properties of steel to which Cu 0.50-1.50%, Ni 0.40-0.80, Mo 0.20 Max. have been added. These alloy additions act as ferrite strengtheners and thus are not accompanied by air hardening. Steel is produced in 2 C-grades 0.12% max. and 0.30% max. which show physical properties about double those of plain steels without the alloy. These steels also have potentialities for further increase in strength by age-hardening. WLC (11b)

Titanium in Metallurgy. M. A. HUNTER & A. JONES. *Transactions Electrochemical Society,* Vol. 66, 1934, pages 21-32. Ti can be produced in the pure state and finds limited use in metallurgy. Alloys of Ti with Fe, Cu, Al, Ni and Mn, are also available as sources of supply and find extensive applications. In the iron and steel industry, Ti is used as a minor addition as a deoxidizer and scavenger in cast and malleable iron and low C steels. In alloy steel containing Cr or Ni-Cr, it performs a special function in reducing air hardening and susceptibility to corrosion. In the "Konel" alloys in which Ni predominates, it increases strength at high temperatures by conferring age-hardening properties on the alloy to which it is added. Cu Ti alloys are capable of being age-hardened and have interesting possibilities. In Al alloys, Ti plays only a minor role. (11b)

A New Resistor Alloy, Chromium-Aluminum-Iron. S. L. HOYT. *Metal Progress,* Vol. 28, June 1935, pages 38-40. Describes a new electrical resistance alloy suitable for very high temperature duty in resistance furnaces of 37.5% Cr, 7.5% Al, bal. Fe which has m.p. of 2830° F and density of 6.9. WLC (11b)

The Yield of Steel Wire Under Stresses of Very Small Duration. W. MASON. *Proceedings, Institution of Mechanical Engineers,* Vol. 128, Nov.-Dec. 1934, pages 409-438. By a suitable arrangement, waves of tensile stress were sent along a vertically suspended wire. A permanent strain did not appear until a stress higher than the static yield point had the appropriate duration. In the experiment, if the static yield was 16.3 tons/in.^{2} the wave caused a yield rising from 3.4 to 28.7 tons/in.^{2} in 1.25×10^{-4} sec. and falling to 3.4 again in 0.45×10^{-4} sec. The tests are described in full and it is attempted to establish a connection with the fatigue limit range of stress. Ha (11b)

SOME NOTES ON BETHLEHEM ALLOY STEELS

N-Nickel-Chrome Steels

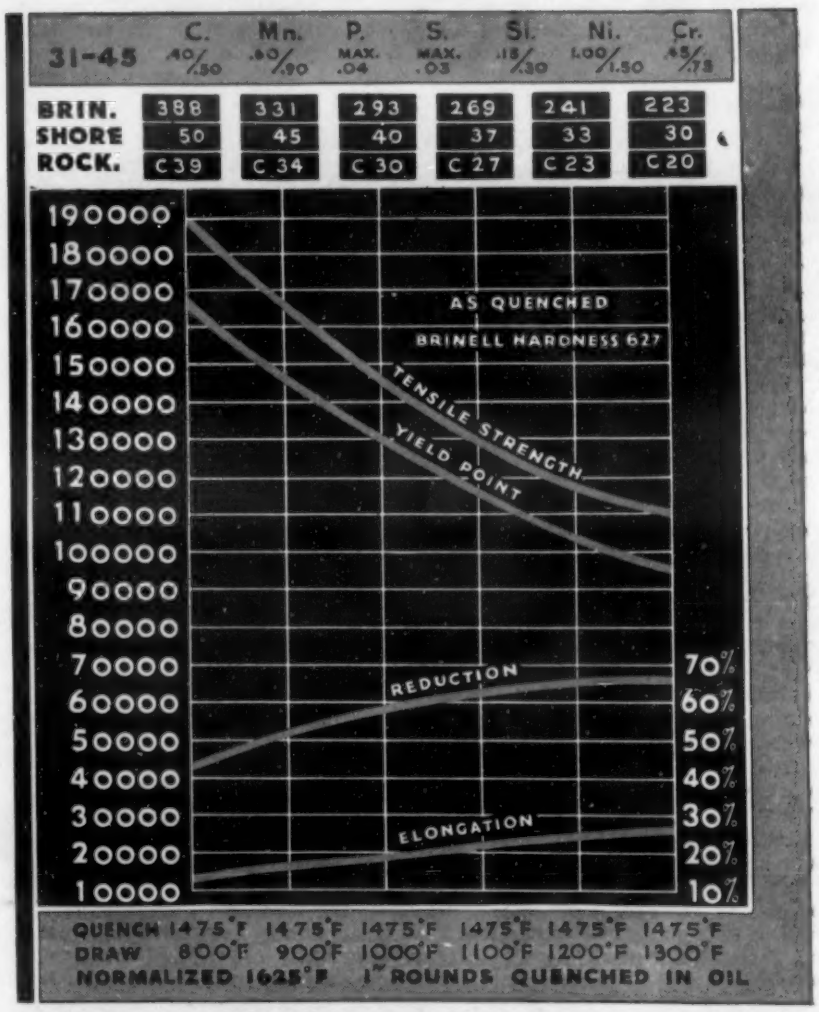
CHROMIUM is essentially a hardening element when alloyed with steel. Nickel imparts greater strength and improved ductility. The combination of nickel and chromium produces a steel carrying the benefits of the added strength of both alloys. Chromium is the more effective in increasing the hardness penetration in the heat-treated condition, while ductility is improved by the nickel. Nickel-chrome steels have found wide industrial use, including very important applications in the automotive industry.

The original Bethlehem "Mayari" Steel was a type of steel similar to the present S. A. E. 31xx Series, the alloying elements in which are 1.00 to 1.50 per cent nickel and 0.45 to 0.75 chromium. This steel is produced with carbon contents in the accepted ranges from 0.10 to 0.70.

Like other alloy steels containing up to 0.25 per cent carbon, this type is ordinarily used for carburized parts such as rock-bit cones, stub shafts, pins, worms, gears and pinions of many types, universal joints, rolls, rocker arms, airplane engine cams, studs, bolts and pins, and finds wide application in such service. Up to 0.35 per cent carbon, it is a water-hardening steel; with a carbon content of over 0.35 per cent, it becomes an oil-hardening steel. Typical uses of 31xx nickel-chrome steels with this higher-carbon content are: connecting rods, rods, master rods and straps for airplane engines, compressor crank-shafts, spindles, tool joints, chain-link stock, engine bolts, superheater bolts, steering knuckles, drive shafts, axles, spring clips, propeller shafts, shovels, picks and similar items. In the 0.30 to 0.45 per cent carbon range, the principal applications include bolts, studs, shafting and gears. As the carbon content passes 0.50 per cent, this grade is widely used for die blocks, tool holders, gears and pinions.

The 32xx Series, which contains 1.50 to 2.00 per cent nickel and 0.90 to 1.25 per cent chromium, has an excellent balance of hardening elements which on heat-treatment results in a high combination of strength and ductility. This series is applicable to parts where the service requirements are more severe than can be met with steels of the 31xx Series.

The 33xx Series, a richer alloy than the 32xx Series, contains 3.25 to 3.75 per cent nickel and 1.25 to 1.75 per cent chromium. The 34xx Series carries 2.75 to 3.25 per cent nickel and .60 to .95 per cent chromium. While both of these grades have very definite applications they are not as widely used as steels falling in the 31xx and 32xx Series.



★ *Physical properties of S. A. E. 31-45, one of the "Mayari" type nickel-chrome steels.* ★

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An Investigation of Spring Steels. J. H. Andrew & G. T. Richardson. *Engineer*, Vol. 159, May 10, 1935, pages 484-485; *Engineering*, Vol. 139, May 17, 1935, pages 525-526, 530-532; *Iron & Coal Trades Review*, Vol. 130, May 3, 1935, pages 756-758, 766. See *Metals & Alloys*, Vol. 6, Aug. 1935, page MA 335L/8. LFM + Ha (11b)

1

Effect of Small Additions of Copper and Nickel to Carbon Steels (Einfluss kleinster Beimengungen von Kupfer und Nickel auf Kohlenstoffstähle). H. Bennek. *Technische Mitteilungen Krupp*, Vol. 2, Dec. 1934, pages 129-133. See *Metals & Alloys*, Vol. 6, July 1935, page MA 299L/8. MG (11b)

Modern Products in Ferrous Metallurgy (Les Produits Métallurgiques Ferreux Modernes). Paul Bastien. *La Technique Moderne*, Vol. 27, July 1, 1935, pages 430-438. Reviews following products (1) Steels: (a) high strength steels: alloy steels are discussed, treatment and properties are given. (b) Corrosion resisting steels: Cr, Ni-Cr, Ni-Mo, Ni-W ferritic or austenitic steels are reviewed, in each case chemicals to which the steel is resistant are described. A special section deals with semi-stainless steels of low alloy content such as Cr, Ni, Mn steels. (c) Heat resisting steels: these steels must resist plastic flow and, at the same time, resist scaling. Martensitic steels stabilized by suitable additions as well as complex austenitic steels are studied. Special attention is given to steels used in exhaust valves. (d) Tool steels: materials available for each kind of work: pressing, sawing, cutting, stamping, etc., are reviewed. (e) Magnet steels: new steels containing 30% Ni, 12% Al developed in Japan are dealt with. (2) Cast Fe: (a) high strength cast Fe: a matrix of pearlite is necessary, the quality is further improved by alloy additions. Ni is said to be the most used among those elements. Heat treatment is more and more applied to alloy cast Fe, ordinary cast Fe does not respond sufficiently to treatment. (b) Corrosion resisting cast Fe: kinds of cast Fe studied are those containing 13-19% Si and Ni-Cu austenitic ones. (c) Heat resisting cast Fe: mode of destruction of cast Fe when heated is first described: growth, cracking, gas penetration and scaling. Common and alloy cast Fe are discussed, interest of austenitic cast Fe of the Ni-resist and Nicrosilal types is pointed out. (d) High hardness and wear resisting cast Fe. FR (11b)

2

Iron Nickel Alloys (Zur Kenntnis der Eisen-Nickel-Legierungen). O. Dahl, J. Pfaffenberger & N. Schwartz. *Metallwirtschaft*, Vol. 14, Aug. 23, 1935, pages 665-670. A large number of Fe-Ni-Cu alloys was made from pure metals with the addition of Mn, of which an average of .6% was retained, and these were rolled into strips, heat treated, and used for electrical conductivity, hardness and magnetic tests. The solubility limits of the ternary alloys were determined by conductivity and hardness tests at various temperatures and by microscopic examination. At 1050° C. the peak of the curve is at 43% Ni, at room temperature at 65%. Most of the alloys respond to heat treatment. The increase in hardness by drawing after either quenching or furnace cooling from 1050° is not great, the maximum being 80%. The Brinell of the quenched alloys varies from 70 to 140 and the maximum obtainable by drawing is about 200. All alloys can be easily worked in both quenched and drawn states. The magnetic properties, especially of the alloys low in Fe, respond much more to heat treatment than the hardness. Coercive force and hysteresis curves were determined on furnace cooled and air cooled samples, and for some of the alloys the change in hysteresis loop on drawing at rising temperatres after air cooling. Maximum change in coercive force occurs in the alloy 60 Cu, 30 Ni, 10 Fe, which has .1 Oersted after air cooling and 400 after furnace cooling from 1050°. While the residual magnetism is low on account of the low Fe content, the product coercive force × residual is relatively high in a number of the alloys, comparing favorably with the low Co magnet steels. By cold working after furnace cooling this product can be raised further. These alloys have the advantage over magnet steels of good working properties and corrosion resistance. Curves for 3 alloys, which were drawn for 2 hours at various temperatures after air cooling at 1050°, show that the hardness, conductivity and residual are nearly proportional, reaching maxima at about 600°. The coercive force reaches its maximum at a higher temperature, about 700°. 12 references. CEM (11b)

3

The Progress of the Tension-Elongation Curves of Steel in the Temperature Range of Blue Heat (Ueber den Verlauf der Spannungs-Dehnungs-Schaulinien von Stahl im Temperaturgebiet der Blauwärme). W. Enders & Werner Lueg. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf*, Vol. 7, No. 6, 1935, pages 77-88. The shape of the curve representing elongation as a function of tension in the tensile test is affected very largely by temperature. By means of a specially developed condenser arrangement the changes (discontinuities) occurred only in a narrow temperature range between about 100° and 280° C. It could not be determined with certainty if such discontinuities were due to precipitation phenomena or gas content of the steel. In the range of blue heat, the tensile strength increases in spite of the discontinuities, in all investigated steels the maximum number of discontinuities in this range occurred at slightly lower temperatures than the maximum tensile strength. Slow cooling and annealing of long duration at 200° C. reduced both tensile strength and elastic limit, while notch-toughness was reduced only in steels with high gas content. Numerous curves show the influence of cold-drawing on the discontinuities under various conditions. 9 references. Ha (11b)

4

Ferro-magnetic Alloys and Their Properties (Über die ferromagnetischen Legierungen und ihre Gesetzmässigkeiten). A. Kussmann. *Chemiker-Zeitung*, Vol. 59, Apr. 6, 1935, pages 285-287. The causes of ferro-magnetism from the standpoint of atomic structure and hysteresis are discussed. Non-metallic inclusions in steel and the strains produced by them have an important effect on magnetic properties while impurities in solid solution have no effect. The properties of Fe-Ni alloys and progress in permanent magnets are reviewed. CEM (11b)

Effect of Pre-imposed Stresses on the Strength of Cast Iron (Ueber den Einfluss von Vorbeanspruchungen auf die Festigkeitseigenschaften von Gusseisen). A. Leon & A. Slattenschek. *Giesserei*, Vol. 22, July 19, 1935, pages 353-357. The effect of a pre-imposed compressive stress in axial direction on tensile strength and of axial tensile stress or torsional stress on the compressive strength reduced the tensile strength by about 9%, and the elasticity modulus was reduced hereby by 38%. The usual increase in volume connected with a compression test is reduced by pre-imposed stresses. Pre-imposed tensile and torsional stresses do not materially change the compressive strength. The ratio of true compressive to true tensile strength is practically unchanged by pre-imposed stresses. Ha (11b)

5

The Properties, Characteristics and Uses of Stainless Steel. S. A. Main. *Metallurgia*, Vol. 11, Apr. 1935, pages 155-158; abstract, *Engineer*, Vol. 159, Mar. 22, 1935, page 313. See *Metals & Alloys*, Vol. 6, July 1935, page MA 299R/9. JLG +VSP (11b)

6

Notch Sensitivity of Steel Under Alternating Stresses (Ueber die Kerbempfindlichkeit von Stahl bei wechselnder Beanspruchung). R. Mailänder. *Technische Mitteilungen Krupp*, Vol. 3, June 1935, pages 108-111. If the endurance strength of a material is calculated for notched samples by the usual formula σ_{max}/σ_n a lower value is obtained than for unnotched specimens because the stress in the bottom of the notch is increased. Tests with steels of different composition showed that the characteristic figure for the notch sensitivity is not suitable to express fine differences in the quality of steels, as interior notch effects may lead to an erroneous value of notch sensitivity. No relation could be established between notch toughness and notch sensitivity. Ha (11b)

7

Change of Mechanical Properties of Cast Iron with Chemical Composition (Variation des Qualités méchaniques des Fontes avec la Composition chimiques). H. Mestas. *Revue de Fonderie Moderne*, Vol. 29, July 20/25, 1935, pages 229-232. Very exactly conducted experiments with 26 different compositions of cast Fe (with varying total C, combined C, Si, Mn, P and S) are presented in charts showing bending strength, compressive strength, shearing strength, tensile strength, impact strength and Brinell hardness. General conclusions are: C increases hardness and tensile strength, Si increases toughness and reduces ductility, P and S reduce strength, Mn increases combined C, hardness and strength. An example shows how the charts can be used for selecting the proper composition of a cast Fe for a given purpose. Ha (11b)

8

Use of Chromium-Nickel Steels Tempered at Low Temperatures (L'Utilizziozione degli Acciai Cromo-Nickel rinvenuti a basse Temperature). V. Prever & C. A. Maresca. *Industria Meccanica*, Vol. 17, July 1935, pages 597-603. Tests under repeated torsional stresses with Cr-Ni steels of medium C content have shown that annealing at low temperatures increases the resistance to static and dynamic stresses. The superiority of the resistance to alternating stresses remains also in the case where fairly abrupt changes of sections (recesses) in structural materials exist, but this superiority ceases where the radius of the recess is less than 0.1 mm. The ratio fatigue resistance to tensile stress diminishes considerably with the value of tensile stress itself; in the tests, with samples of greatly varying section, the ratio changed from 0.51 to 0.44, but the absolute values are still high. In general, tempering at low temperatures, between 450° and 600° for a short time, exerts a beneficial influence on the mechanical properties. This confirms the results of Guillet and of Grenet. Ha (11b)

9

Wrought Iron in Today's Industrial Picture. James Aston. *Metals Technology*, Aug. 1935, *American Institute Mining & Metallurgical Engineers Technical Publication* No. 632, 15 pages. A brief history of the manufacture of wrought Fe is given. Wrought Fe is defined by the A.S.T.M. specification. Physical properties and composition are briefly discussed. Typical microstructures are shown. It is stated that better manufacturing facilities have made possible the reintroduction of plates, sheets and other products that have not been available for a few decades. JLG (11b)

10

Progress in Standardization of Ordinary Gray Iron, as Revealed by Questionnaires (Sul Progetto "Uni" di Unificazione della Ghisa Grigia in Getti Ordinari, in Corso di Inchiesta Pubblica). A. Aureli. *Industria Meccanica*, Vol. 17, May 1935, pages 396-400. Questions of composition, testing and dimensions of test specimens are discussed and the present status of standards for gray iron in Italy is reviewed. Ha (11b)

New Free-Machining Alloy Steels Contain Selenium. *Automotive Industries*, Vol. 73, Aug. 17, 1935, page 196. The Palmer patent issued July 30 and assigned to Carpenter Steel Co., Reading, Pa., describes free machining properties imparted to practically all iron and steel products by selenium. It is claimed that less Se is needed than S for the same machinability, that less slag-like material is produced, and presence of Se does not interfere with response to heat treatment. The Se steel so far produced has been melted in electric furnaces. BWG (11b)

Corrosion Resisting Steels. *Edgar Allen-Buell Gazette*, Vol. 1, June 1935, pages 222-225. The 6 types of stainless steels manufactured by the Edgar Allen Company are enumerated and their properties, composition and treatment in working described. Ha (11b)

Heat Treated Gray Iron-Cylinder Liners. W. Paul Eddy, Jr. *Transactions American Foundrymen's Association*, Vol. 6, Feb. 1935, pages 129-147. In an attempt to increase the life of automotive engine cylinders, considerable experimental work with various irons led to the adoption of cylinder liners of an iron with the following composition: T.C. 3.10-3.40%, C.C. .75-.90%, Mn .55-.75%, P max. .20%, S max. .10%, Si 1.90-2.10%, Cr .55-.75%, Ni 1.80-2.20%. These liners are hardened by oil quenching from 1550° F. and are tempered at 350° F. for 2 hours. They have a hardness of approximately Rockwell C50 or Vickers Brinell 530, and a tensile strength of approximately 38,000 lbs./in.^{2} Microstructure after heat treatment consists of a matrix of martensite with scattered cementite particles, and typical flake graphite. A description of machining, heat treating, and assembling operations, as used for the manufacture of production quantities of cylinder liners, is given. An average increase in cylinder life, in heavy-duty vehicle engines, of about 200% has been effected by the adoption of these hardened liners to replace one-piece cylinder blocks of alloy iron having hardness of Brinell 235 with the additional advantage that the liners are renewable when worn out. CEJ (11b)

Improved Properties Extend Uses for Malleable Iron. D. P. Forbes. *Steel*, Vol. 96, June 24, 1935, pages 33-35. See "Malleable Iron—Its Properties and Applications," *Metals & Alloys*, Vol. 6, Sept. 1935, page MA 373L/9. MS (11b)

The Metallurgy of Wire. L. Dwight Granger. *Modern Machine Shop*, Vol. 8, Sept. 1935, pages 21-28, 46. The various uses of wires, types of wire evolved for different purposes (fence, nail), processes of making wire, chemical composition and metallurgical and metallographical features are discussed in a general way. Ha (11b)

12. EFFECT OF TEMPERATURE ON METALS AND ALLOYS

L. JORDAN, SECTION EDITOR

The abstracts in this section are prepared in co-operation with the Joint High Temperature Committee of the A.S.M.E. and the A.S.T.M.

Influence of Time on Creep of Steels. A. E. WHITE, C. L. CLARK & R. L. WILSON. *Preprint, American Society for Testing Materials,* June 1935, 19 pages. Extended-time creep tests were conducted at 1000° F. on a plain C steel of the S.A.E. 1015 type (C 0.15, Mn 0.50, Si 0.23%) and a Cr-Si-Mo steel (C 0.07, Mn 0.42, Si 0.72, Cr 1.25, Mo 0.54%). Certain of the stresses for the alloy steel were so selected that fracture would result at various periods of the test, thus producing the complete time-elongation curves. These larger stresses are considerably greater than any which would normally be used in commercial practice. The fractured specimens were subjected to metallographic, X-ray and hardness examinations to determine the extent to which the structural and deformation characteristics were dependent on the time required for rupture. In all the creep tests, the rate of creep decreased and thus the creep strength increased during the earlier periods of the test and the magnitude of the changes, for the given temperature, depended both upon the steel and the stress being considered. If the stress is sufficiently great, the creep rate will increase after a certain time and the time required for this change varies inversely with the stress. The reported creep stresses will, therefore, vary depending upon the length of time the tests are conducted. In the case of the C steel at 1000° F. the amount of variation was not excessive. The changes were, however, more pronounced with the alloy steel due to the considerably greater stresses employed. This would indicate that the observed differences with time may be proportional to the magnitude of the creep rate being considered. The ability of relatively short-time creep tests (500 to 2000 hr.) to prophesy the behavior under more extended time periods varies, for the given temperature, with the steel considered. With a steel in which the net strain-hardening effect is slight, such as the plain C steel in this case, the time factor is not of great importance and a test of 500-hr. duration gives a good indication of the load-carrying ability for periods of several thousand hours. For other cases in which the resulting strain-hardening effect is more pronounced, such as with the alloy steel, the reported values vary considerably over the period of 500 to 2000 hrs. In both of the cases considered, the 500-hr. test gives lower creep strength values than does the 1000-hr. test and also values which correspond more closely with those obtained from tests of several thousand hours duration. The results would appear to indicate, therefore, that at least in the two cases considered, the 500-hr. test is a more conservative criterion than the 1000-hr. test. The time required for rupture influences the resulting ductility values but not in a uniform manner. The fractured creep specimens of the alloy steel all possessed a lower ductility than that obtained from the short-time tension test at the same temperature, but the variations in the values of the creep specimens were not proportional to the time required for fracture. Neither were the changes of sufficient magnitude to cause undue alarm. On the basis of the metallographic examination, structural changes were produced during both the tension and creep tests. All of the fractured specimens possessed a smaller grain size than the original steel and the grain size of the creep specimens became smaller, the greater the time required for rupture. The X-ray examination showed that the original steel was relatively strain free, the creep specimens were strained, while the short-time tension specimen was not only strained but considerable crystal fragmentation had occurred. A greater degree of strain-hardening was evident in the short-time tension specimens than in the creep specimens. The maximum hardness of the creep specimen decreased as the time required for rupture was increased. The changes observed from the metallographic, X-ray and hardness examinations may be accounted for either on the assumption of a difference in the mechanism of deformation in the short-time tension and creep specimens, or that, in the case of the creep specimens, the time held at temperature was sufficient to remove certain of the effects of the deformation. VVK (12)

Mechanical Properties of Cast Iron at Elevated Temperatures (Die mechanischen Eigenschaften von Gusseisen bei höheren Temperaturen). R. BERTSCHINGER & E. PIWOWARSKY. *Die Giesserei,* Vol. 22, July 5, 1935, pages 325-333. Literature on the subject is critically reviewed. Experiments to determine the dependence of bending strength, Brinell hardness and compressive strength on Si and C content were made on C-rich types of Fe of a near eutectic composition containing the smallest possible proportions of P, S and Mn. The stresses set up during the casting of the material which determine the minimum strength have no importance between room temperature and 400° C.; a decided decrease in strength starts between 380° and 420° C. Within these limits, Si did not exert any effect. Coarse graphite decreases the strength at higher temperatures; the finer the graphite the higher the absolute values of strength even at 500° C. Bending strength and compressive strength at room temperature are reduced to half their value at 550° C. The modulus of elasticity between 20° and 350° C. did not show a consistent behavior; while in some tests it decreased steadily with increasing temperature, in other tests a maximum was found between 100° and 150°. Coarse graphite decreased the modulus to between 3000 and 4000 kg./mm.² 37 references. Ha (12)

Creep Characteristics of Aluminum Alloys. R. R. KENNEDY. *Preprint, American Society for Testing Materials,* June 1935, 14 pages; *Iron Age,* Vol. 135, June 27, 1935, pages 26-27, 66. Caution should be used in applying the results of creep tests to the design of airplane-engine parts due to the difference between test conditions and service conditions. In a creep test, both the load and the temperature are constant for the period of the test while in an airplane engine the parts are subjected to vibration, often to alternating tensile and compressive stresses and the temperature fluctuates according to operating conditions. The results of creep tests should be of value, however, in indicating the relative behavior of the various alloys at operating temperatures. Curves and tables give the creep rates of 9 Al alloys at 400° and 600° F. at loads of from 1300 to 22,500 lbs./in.² Static tensile properties are also given. The creep rates of the alloys varied over a wide range. Sand-cast Al-Cu-Ni-Mg alloy had the best creep characteristics of the alloys tested. Some of the newer wrought and cast alloys were markedly inferior to this alloy in that respect, although their mechanical properties at room temperature were superior in some cases and they have better casting and forging properties. 9 references. VSP + VVK (12)

—

Some Tests on Tin Bronzes at Elevated Temperatures. J. W. BOLTON. *Preprint, American Society for Testing Materials,* June 1935, 9 pages. Bronze of the alloy B-61 type (A.S.T.M. Standard Specifications for Stream or Valve Bronze Sand Castings) is very well suited for use at 500° F. and possibly up to 550° F. The composition tested was Cu 87.14, Sn 6.22, Zn 4.61, Pb 1.83%. It is

2 unsuited to applications where the temperature of the metal structure reaches 600° F. The design stress at 500° F. should be limited to 5000 lbs./in.². At 500° F. alloy B-61 has a "limiting creep strength" (based on that stress which produces a rate of flow less than 0.1% in 10,000 hr. after the first 500 hr. of creep tests, running up to 2100 hr. duration) of about 8000 lbs./in², or about 1.6 times the recommended maximum design stress. This and the fact that the metal shows no evidence of embrittlement at this temperature confirms the application range indicated in the tentative specification as conservative and proper. In case of bronzes containing the alpha-delta, eutectoid including the compositions contemplated by Specification B-60 (the composition tested was Cu 87.6, Sn 10.18,

3 Zn 2.02%) and especially the high tin alloy 88-10-2, the tests indicate that at 500° F. the load-carrying ability is lower than that of alloy B-61, and there is distinct evidence of embrittlement. Microscopic study suggests that this embrittlement is caused by the penetration or possibly the formation of the eutectoid along grain boundaries. This condition becomes very apparent at 600° F. It is the author's opinion that from a code and specification viewpoint the use of such high-tin alloys probably should be confined to 450° F. and permissible stress of 5000 lbs./in.² at that temperature. VVK (12)

4 **Some Alloys Having Great Thermal and Magnetic Stability.** PAUL D. MERICA. *Metal Progress,* Vol. 28, June 1935, pages 41-45. Describes the thermal stability of alloys of high m.p. metals, Fe, Ni, Co, W, and Mo, with Fe-W-Co, 35-30-25 as an example in which the hardening precipitate remains in its fine and effective size even after long exposure to high temperature. Production of high "magnetic hardness" in Fe-W-Co, 67-18-15 is described with mention of other systems of similar properties. This series of articles is concluded with brief discussion of the theory of age-hardening. WLC (12)

5 **Low Temperature Sleeving of Cylinder Blocks.** *Mechanical World & Engineering Record,* Vol. 47, May 3, 1935, page 44. Sleeves pressed into cylinders tend to collapse and confine the piston. An advantage of the cold method of sleeving (in liquid O_2 at —183° C.) is that the sleeves continually tend to expand. WH (12)

6 **Staybolt Leakages on Cooling in Locomotive Fire Boxes (Beitrag zur Frage der Erkaltungsundichtigkeit von Stehbolzen in der Lokomotivfeuerbuchse).** HERMANN BLOMBERG. *Organ für die Fortschritte des Eisenbahnwesens,* Vol. 90, May 1, 1935, pages 157-162. Reports experiments on the behavior of various connection methods for bolt and fire box with reference to obstructed thermal expansion. The conditions in locomotive fire stays and plates have been imitated and various types of joints were studied with the following results. In the case of restricted thermal expansion not only the bolt but also the packing ring becomes permanently deformed and leaking occurs on cooling. The bolt becomes loose if the

7 expansion coefficient of the bolt material is larger than that of the plate. The resulting play is reduced if the expansion coefficient of the bolt material is smaller than that of the plate or if both are made of the same material. These conditions hold only if bolt and plate are heated to the same temperature. If the bolt becomes hotter than the plate, the favorable ratio of thermal expansions is upset. A bolt material of higher thermal conductivity exerts a favorable influence upon the tightness at the joint. Bolt and plate hole tend to assume the same geometrical form. This tendency is aided by a material of good working properties, i.e. of lower hardness. WH (12)

8 **Magnetic Properties and Critical Currents of Superconducting Alloys.** G. N. RJABININ & L. W. SCHUBNIKOW. *Physikalische Zeitschrift der Sowjetunion,* Vol. 7, No. 1, 1935, pages 122-123. In English. Experiments on a Pb-Tl alloy corresponding to the composition $PbTl_2$ and on a 65/35 Pb-Bi alloy. Up to a definite field-strength, which depends on temperature, the induction remains nearly 0. In this region the behavior of alloys and pure metals is the same. In a certain field interval, induction increases with field strength, gradually approaching the value characteristic for the non-super-conducting metal. At a second critical field strength, (1700 Gauss at $T = 2.11°$ K.) the alloy loses its superconductivity. Gorter's suggestion that the superconducting state is characterized by $\mu = 0$ and that the transition to the ordinary state with $\mu = 1$ may be considered as a phase-transition to which thermo-dynamics may be applied does not hold for alloys. Further test results on the relation between critical current and diameter of wires are reported briefly. EF (12)

9 **On the Oxidation of Iron and Steel at High Temperatures and the Structure of the Scale.** KATSUZIRO ENDO. *Kinzoku no Kenkyu,* Vol. 12, May 1935, pages 235-246. In Japanese. See *Metals & Alloys,* Vol. 6, Sept. 1935, page MA 374L/4. KT (12)

10 **Experience with Welded Joints for High Pressure and Temperature Steam Pipe Work.** A. G. BUGDEN. *Welder,* Vol. 7, June 1935, pages 586-592, 607. Tests carried out on pipe work seem to show very clearly that flanges and bolts on a joint of this type are not necessary and that with satisfactory welding the equivalent of a continuous pipe can be obtained. The joint withstood successfully for a period of 1460 hrs. a max. combined stress due to internal pressure alone of 80.5% of the proportional limit, and in the weld 87% of this limit. An additional bending moment of 12 tons-ft. increased the combined stresses to 89.5% which was withstood for a period of 1220 hrs. Practical experience with such pipes showed the all-welded joint to be superior to flanged and bolted joints under high pressures and temperatures. Ha (12)

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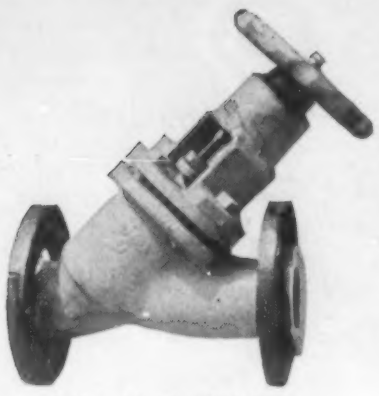

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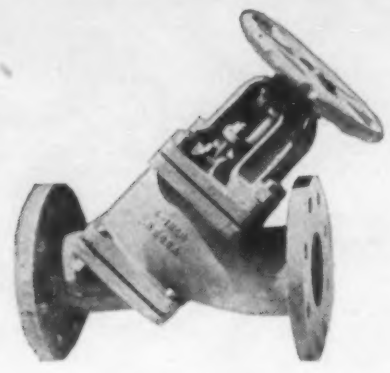

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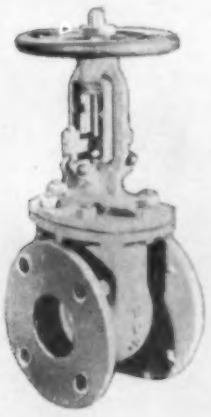

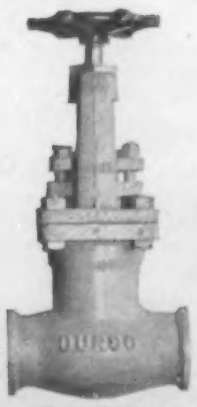

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13. CORROSION AND WEAR

V. V. KENDALL, SECTION EDITOR

1

Nature of Corrosion Phenomena with Oxygen Depolarization (Ueber das Wesen der Korrosionsvorgänge mit Sauerstoff-Depolarisation). G. W. AKIMOW, S. A. WRUZEWITSCH & H. B. CLARK. *Korrosion & Metallschutz*, Vol. 11, July 1935, pages 145-156. All corrosion phenomena, in air and water, such as rusting of Fe, corrosion of Al and Zn, are due to electrochemical cells with O depolarization. A theory is developed and formulas established for the changes going on during corrosion. It is concluded that, after a stationary condition is established, the depolarization current remains constant and the potential difference of the system depends on the electrical resistance of the system. The importance of protective films is pointed out. Ha (13)

2

Black Spots on Tin and Tinned Ware. SVEN BRENNERT. *Technical Publications International Tin Research & Development Council*, Ser. D, No. 2. Aug. 1935, 27 pages. Formation of black spots on Sn, especially on dairy equipment, is shown to be due to electrochemical corrosion. The products are white basic Sn salts, largely stannous oxide, and dark products which adhere firmly to the base metal. Black spots start to form only after a definite dissolution potential is reached varying with the composition of the solution, but once formed they may grow in dilute solutions at less noble potentials. As with many other metals, Sn is ennobled by formation of an air-formed protective film. Sn begins to corrode with formation of black spots at points of weakness such as scratches after the protective film has formed. Formation of black spots can be prevented by reducing the potential of the Sn, as by keeping a less noble metal like Zn or Al in contact with the Sn surface. (This is comparable to the well known method of hanging Zn plates in boilers to reduce corrosion). It is also possible to produce by anodic oxidation an artificial protective film that offers quite effective protection against corrosion. Most of the experimental work has been done on neutral or near neutral solutions of NaCl, Na_2SO_4 or $NaNO_3$. Increasing the Cu content of the Sn was found to have no effect on the ennobling rate or of the dissolution potential of the Sn. BWG (13)

3

Antimonial Lead for Water Pipes (Antimonhaltiges Blei für Wasserleitungsrohre). O. BAUER & G. SCHIKORR. *Metallwirtschaft*, Vol. 14, June 14, 1935, pages 463-479. Physical and corrosion tests were made on 8 grades of Pb, containing from .003 to 1.40 Sb. The addition of Sb raised the tensile strength and hardness of Pb, .9% Sb raising them 40%. The wall thickness of water pipes can be reduced correspondingly by using antimonial Pb. Distilled H_2O free from CO_2 attacked pure Pb strongly. The addition of .35% Sb reduced the corrosion 60% and the maximum reduction was obtained with .8% Sb. With increasing CO_2 content in the H_2O a protective coat was formed on the pure Pb and the corrosion reduced almost to that obtained with .8% Sb. The local drinking water attacked Pb much less than distilled H_2O free from CO_2, and the difference between pure and antimonial Pb was slight. A minimum attack was obtained with .8% Sb. H_2O containing humus attacked antimonial Pb more than pure Pb, but the attack was not much greater than with drinking water. Antimonial Pb was attacked less than pure Pb by 3% NaCl, artificial North Sea water and $Ca(OH)_2$ solution, but more than pure Pb by KNO_3 solution and moist lime mortar. It is not advisable to lay Pb pipes in lime mortar especially if the mortar is apt to become moist. CEM (13)

4

Wear of Steel Rails (La question de l'usure des rails d'acier). ERNST COTEL. *Revue de Metallurgie*. Vol. 32, Mar. 1935, pages 137-144. See *Metals & Alloys*, Vol. 6, July 1935, page MA 302R/4. JDG (13)

5

Evolution of Weatherproof Steels (Die Weiterentwicklung witterungsbeständiger Stähle). K. DAEVES. *Mitteilungen der Kohle- und Eisenforschung*, G.m.b.H., Vol. 1, Feb. 1935, pages 1-8. Cu steels have shown a high resistance to rusting in air, and to attack by combustion gases while the resistance to fresh and sea water depends largely on local conditions. Recent tests have established the fact that solubility tests in acid do not represent the actual rusting resistance of steels. Contrary to expectations from such tests, a P content of more than 0.06% increases the resistance of Cu steels against atmospheric influences quite considerably, by whatever process the steel was made. Cu-Sn steels are also improved by a higher P content. A dark brown, smooth and firmly adhering protective layer of rust is formed by P, the blue rolling scale is easily shed and these steels behave better under a coat of paint than normal steels. 7 references. Ha (13)

6

Corrosion in the Interior of Water Pipes and Its Prevention (Korrosion im Inneren von Wasserleitungen und deren Verhütung). F. EISENSTECKEN. *Paper Fourth Corrosion Congress Verein deutscher Ingenieure, Verein deutscher Eisenhüttenleute, Deutsche Gesellschaft für Metallkunde and Verein deutscher Chemiker*, Nov. 20, 1934, Düsseldorf, pages 22-31. O and CO_2 in combination with the salt content of H_2O are the main sources of destruction of water pipes. Still or slow running H_2O attack more than rapidly running H_2O. Corrosion is hardly encountered at a speed of .5 m./sec. Remedies are suitable pretreatment of water, decrease of detrimental CO_2 content by airing, admixture of lime water etc. and protective layers. A higher O content in water in general decreases corrosion by formation of protective layers. However, water supersaturated with O, as may result from change of pressure or increase of temperature, may form air bubbles causing corrosion in pits. Enameling and bitumens are the chief measures of protection. Perfect continuity of such coatings must be achieved. GN (13)

7

Comparative Corrosion Tests with Soft Steel Sheets (Ueber vergleichende Korrosionsversuche mit weichen Stahlblechen). F. EISENKOLB. *Korrosion & Metallschutz*, Vol. 11, July 1935, pages 156-162. The usual rapid corrosion testing methods were compared with long-time tests in order to find an eventual relation. The results showed that an exact parallelism does not exist, the results of short-time tests must always be used with caution. Sequence of corroding agents and their strength play an important part. Cu steels, for instance, precipitate Cu during destruction and form thus a protective film which prevents further rusting. Long-time tests should be made not only in one certain direction but under varying conditions and with different attacking agents. Ha (13)

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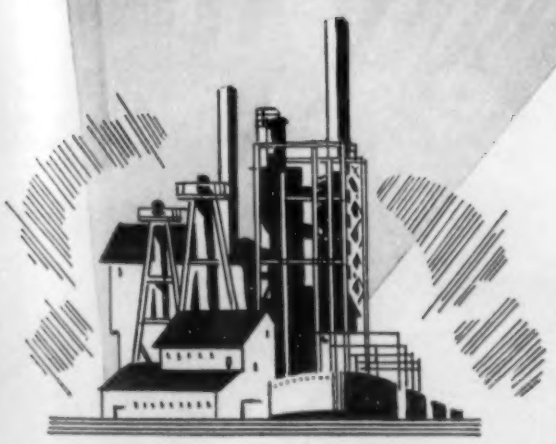

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Acid-resisting Alloy "Ferrosilid." Its Properties and Production. S. V. Malashenko. *Vestnik Metallopromishlennosti*, Vol. 15, Mar. 1935, pages 113-120. In Russian. A survey of Fe-Si alloys used for corrosion resisting purposes compiled largely on the basis of published data. (13)

The Use of Sodium Sulphite as an Addition to Alkaline Detergents for Tinned Ware. S. Kerr. *Journal Society of Chemical Industry*, Vol. 54, July 5, 1935, pages 217T-221T. The detergent chiefly used in the dairy industry is a hot solution of Na_2CO_3. Regardless of the concentration or the temperature, however, dairy vessels are seriously attacked by lactic acid with the formation of a soluble stannite salt when the vessels are Sn coated. The corrosion reaction was recognized as one of oxidation only, temperature apparently having negligible influence. The use of a reducing agent possessing the requisite detergent and corrosion inhibitive properties appeared obvious. Among a large number of reducing agents examined, Na_2SO_3 was shown to be the most practical as regards price, relative stability in its solid form, high solubility in water and alkaline solutions and satisfactorily inhibitive to Sn corrosion. A ratio of 1 part Na_2SO_3 to 10 parts crystallized Na_2CO_3 is recommended. This solution retains its efficiency at 40°, 55°, 70°, 85° and 100° F. respectively. Experimental data supplement the paper. AAA (13)

The Corrosion of Ordinary and Austenitic Cast Irons (La corrosion des fontes et les fontes austénitiques). Marcel Ballay. *Métaux (aciers Spéciaux, Métaux et Alliages)*, Vol. 9, Oct. 1934, pages 378-386. The current corrosion theory is that, in an ionized solution, graphite in cast iron constitutes the noble element of a couple thus favoring corrosion in an oxidizing medium; in non-oxidizing medium, graphite is polarized and thus the iron is less corroded than steel. A series of irons and steels have been tested for several hours in 2N HNO_3, HCl and H_2SO_4. The following results illustrate the relative rate of corrosion of austenitic irons and steels.

Steels & Irons	*Pearlitic Iron* A.	*Austenitic Iron* B.	C.	*Pearlitic Carbon Steel* D.	*Austenitic Steel* E.
Chemical Analysis					
Carbon	2.97%	2.97%	2.97%	1.09%	0.79%
Manganese	0.76%	1.33%	1.33%	0.10%	1.50%
Silicon	2.28%	3.08%	3.08%	0.14%	0.19%
Sulphur	0.062%	0.062%	0.062%	0.014%	0.012%
Phosphorus	0.56%	0.56%	0.56%	0.03%	0.095%
Nickel	—	13.92%	13.92%	0.10%	24.0%
Chromium	—	1.41%	3.20%	0.16%	2.30%
Copper	—	6.22%	6.22%	—	—
Heat Treatment				Annealed 825° C. furnace cooled	Water quenched from 1050° C.
Corrosion loss in g./m.²/hr. after					
51 hrs. in 2N H_2SO_4	72.5	0.08	0.08	85.0	0.10
51 hrs. in 2 N HCl	115.0	0.15	0.15	2.14	0.15
21½ hrs. in 2 N HNO_3	268.0	275.0	273.0	358.0	380.0

Another austenitic iron (2.94% Total C, 2.16% Si, 0.40% Mn, 0.043% S, 0.055% P, 15.63% Ni, 5.76% Cu, 1.28% Cr) in 5% by volume H_2SO_4, as cast lost 0.02 g./m.²/hr., after the iron was heated for 320 hrs. at 500° C. it lost 11 g./m.²/hr. Another austenitic iron with less Ni (3.24 total C. 1.19 Si, .067 P, 1.38 Mn, 7.86 Ni, 5.65 Cu, 1.04 Cr) lost 0.09 g./m.²/hr. when tested as cast and 72 g./m.²/hr. after heating for 320 hours at 500° C. The following limit of composition is recommended for non-corrosive austenitic irons: Total C 2.75-3.10%, Si 1.25-2.00%, S 0.04-0.12%, P 0.04-0.30%, Mn 1.00-1.50%, Ni 12.00-15.00%, Cu 5.00-7.00%, Cr 1.50-4.00%. GTM (13)

Knowledge and Research in the Field of Corrosion Protection of Pipes (Erkenntnisse und Forschungsaufgaben auf den Gebiete des Korrosionsschutzes von Rohren). W. Schneider. *Paper Fourth Corrosion Congress Verein deutscher Ingenieure, Verein deutscher Eisenhüttenleute, Deutsche Gesellschaft für Metallkunde, and Verein deutscher Chemiker*, Nov. 20, 1934, Düsseldorf, pages 73-76. The corrosion occurrences take place within a heterogeneous system in which the corroding metal, in contact with gaseous, liquid or solid substances, endeavors to pass into a more stable state of smaller energy, to transform into an oxide or another chemical compound. To explain the corrosion occurrences becomes difficult due to the fact that they take place on the metal surface. Our knowledge of the structure of the metallic surface, however, is still very limited. Only by applying slow electron rays is it possible to get an insight into the surface structure. The theory that the metal surfaces do not show the characteristic properties of metals since they do not contain free conducting electrons seems to be a satisfactory explanation. This theory has been developed on the base of conductivity measurements of extremely thin metal skins. Electrochemical theories on passivity and formation of oxide skins are still used most effectively. In using pipes the formation of flow potentials should be especially considered. Proper treatment and application of metals and treatment of the materials in contact with the metals is most important for avoidance of corrosion. GN (13)

Prevention of Corrosion in Water Heaters by Water Treatment (Vermeidung der Korrosion in Warmwasserbereitern durch Wasserbehandlung). E. Naumann. *Paper Fourth Corrosion Congress Verein deutscher Ingenieure, Verein deutscher Eisenhüttenleute, Deutsche Gesellschaft für Metallkunde and Verein deutscher Chemiker*, Nov. 20, 1934, Düsseldorf, pages 55-60. Paper discusses the physical, physico-chemical and chemical methods of water purification for removing the ingredients, particularly O_2 and CO_2, that cause corrosion. The physical methods are rarely used because they have proved rather ineffective. Among the physico-chemical methods is the removal of O_2 by conducting heated H_2O over chips of Zn or brass and the Aquasol method in which a thin protective layer is formed on the heater walls by the admixture of colloidal substances to the water. Most important are the chemical methods of water treatment. O_2 is bound by addition of sodium sulphite, CO_2 by soda or caustic soda. More recently sodium phosphate is applied, forming a layer of iron phosphate on the walls. GN (13)

1 **Requirements Met at Present by Corrosion and Heat Resistant Iron and Steels (Welche Anforderungen können wir derzeit an korrosions- und hitzbeständige Eisen- und Stahlsorten stellen).** L. Aissner. *Petroleum*, Vol. 31, Apr. 10, 1935, *Supplement* pages 1-7. A review of special properties of structural materials suited for severe corrosive service conditions and of factors influencing the chemical resistance of alloys. Diagrams are presented showing composition of corrosion resistant alloys in the ternary Ni-Cr-Fe diagram, thermal conductivity in relation to C. Si, Cr, Ni, Mn content, deep drawing properties of open-hearth, and 18/8 Cr-Ni-steels, strain hardening of Ni-steel, low C-steel and 4 grades of Ni (0.27-10.9% Ni)-Cr (13.5-20.5% Cr)-steels in relation to amount of cold work induced, recrystallization diagram of 16% Cr-steel, dilatation of ordinary and Cr-Ni-steels and tensile strength and yield point curves of open-hearth, plain C, medium and high Cr steels between 20° and 800° C. Further microphotographs show twin bands in austenite, carbide precipitation at grain boundaries, etc. EF (13)

2 **Corrosion from Products of Combustion of Gas—Part II. Tube Experiments. 34th Report of the Joint Research Committee of the Institution and Leeds University.** James W. Wood & E. Parrish. *Institution of Gas Engineers, Communication* No. 100, Nov. 6-7, 1934, 47 pages; *Gas World*, Vol. 101, Nov. 3, 1934, pages 456-457; Nov. 10, 1934, pages 499-502; Dec. 15, 1934, pages 643-645; *Gas Journal*, Vol. 208, Nov. 14, 1934, pages 527-530; Dec. 5, 1934, pages 742-744; *Engineering*, Vol. 138, Dec. 7, 1934, page 633. See *Metals & Alloys*, Vol. 6, Aug. 1935, page MA 338R/6. AHE (13)

3 **Checking Bridge Corrosion.** *Railway Engineering & Maintenance*, Vol. 31, June 1935, page 341. Mohawk Division of the New York Central Ry. checks corrosion by swabbing or painting corroded bridge members with oil. The most serious corrosion has been about the ends of the structures. This is due to the accumulation of cinders, stack soot and other debris on the bridge seats. The oil used has an asphalt base and is similar to that which the road has applied for a number of years to its rail and track fastenings. Rust is removed only superficially since the oil penetrates and loosens a limited film of rust or scale and effectively retards further corrosion. WH (13)

4 **Wire Rope Research. Annual Report of the Safety in Mines Research Board.** *Iron & Coal Trades Review*, Vol. 131, Aug. 23, 1935, pages 276-277. Abridged results. Effects of hemp and other fiber cores on internal corrosion, rust-protective coatings, protective action of oil films, effects of galvanizing, reason for fractures are discussed. Ha (13)

5 **Corrosion-Resisting Non-Ferrous Alloys.** H. Moore & E. A. G. Liddiard. *Journal Society of Chemical Industry*, Vol. 54, Aug. 30, 1935, pages 786-795. The corrosion resistance of the non-ferrous alloys is discussed in detail. The chemical behavior of Al, Zn, Cu, Sn, Pb, Ni and Mg against various corroding media is shown. Alloying these elementary constituents accomplishes a twofold purpose viz., a higher resistance to corrosion and improvement in physical properties. 41 references. AAA (13)

6 **Corrosion in Refrigerating Plants.** W. Nolcken. *Transactions Institute of Marine Engineers*, Vol. 67, Part 2, Mar. 1935, pages 22-23. In the publication of the Department of Scientific & Industrial Research, Report of the Food Investigation Board for the Year 1933, page 222, the article "Corrosion in Refrigerating Plants" advances a theory which in the author's opinion may be viewed from a different angle. It is denied that Ca-salts are the cause of corrosion, which is attributed to the presence of free HCl in the system. Cu plating of the piston of methyl chloride plants does not take place as long as the inner surface of the Cu tubing is clean. In American practice, particular attention is paid to the internal finish of the Cu piping, but not so in Great Britain. Effective elimination of H_2O usually cures all other "chemical" troubles in the machine. The author's "own limited experience" with silica gel driers fitted to methyl chloride machines has not been very successful. WH (13)

7 **The "Probability" of Corrosion.** R. B. Mears & U. R. Evans. *Transactions Faraday Society*, Vol. 31, Mar. 1935, pages 527-542. Contains bibliography. Data are given in the form of graphs and tables, of the influence of 16 external variables on the probability of corrosion and on the conditional velocity of corrosion during the early stages of corrosion. Different varieties of Fe and of steel were used. Drop tests and scratch tests were used. Very few drops which had not developed corrosion within 15 minutes did so within 64 hours, or probability is approximately independent of time. Corrosion velocity is also independent of time. Probability and conditional velocity are raised by increasing the exposed area. Probability is decreased but conditional velocity increased by raising the O_2 concentration in O_2-N_2 mixtures. Using 100% O_2 and 0.07M $NaHCO_3$, increasing the time of pre-exposure to dried air before testing decreased the probability of corrosion from 84% for 0.25 min. pre-exposure to 27% for 1024 min. pre-exposure. Increasing the temperature of experiment from 0° to 25° C. raised the probability and conditional velocity. Lowering the temperature of pre-exposure from 12° to 0° C. or increasing it from 12° to 25° and 100° C., enhances the probability. The probability increases to 100% as the concentration of KCl is increased to 0.01M or over. The conditional velocity increases to a maximum around 0.01M KCl and then decreases slowly as the concentration is further increased. The sulphate ion gave higher probability than chloride ion but lower conditional velocity. Iodine and nitrate ions gave low probability and conditional velocity. The sulphate ion is most effective in overcoming the inhibitive increased probability but larger amounts decreased it to zero. The intensity of corrosion and conditional velocity tends to increase with increase in concentration of inhibition. K_2CrO_4, K_2HPO_4 and K_2CO_3 were tested as inhibitors and the first was most powerful. There is a range over which pH has little influence on probability which can be below 100% in acid solutions. CO_2 in atmosphere has little effect on probability but doubles conditional velocity; SO_2 markedly increases probability and velocity. Pretreatment of surface has a marked effect partly due to organic matter being left on surface. As depth of scratch increases, probability of corrosion increases. The presence of a new crack adjacent to an old one decreases probability of attack on old one but invariably markedly increases probability of attack at the new one. Different varieties of distilled water were tested. It is developed that the protective film is porous, the number of pores being smaller as the pore size becomes larger. The film is protective when the largest pore blocks itself with corrosion products, retarding corrosion before it is visible. The air formed primary film and the secondary film of corrosion products contribute to protect the metal. PRK (13)

14. APPLICATION OF METALS AND ALLOYS

Powder Metallurgy (Metallkeramik) Supplement. FRANZ SKAUPY. Verlag Chemie, Berlin, 1935. Self-cover, 6 x 9½ inches, 10 pages. Price 1 RM.

Since the appearance of the original book in 1930, considerable development has taken place in this field. The greatest advances have been made with the metals, iron and nickel, as well as in the production of porous, so-called oilless bearings. This supplement brings up-to-date the information contained in the original (reviewed in *Metals & Alloys*, Vol. 1, Oct. 1930, page 806.)

Richard Rimbach (14)-B-

All-Metal Coaches of the Milan Northern Railway (Ganzmetall-Personenwagen mit Brill-Drehgestell der Mailänder Nordbahn). L. SCHNEIDER. *Organ für die Fortschritte des Eisenbahnwesens*, Vol. 90, June 15, 1935, pages 220-221. The new all-metal coaches described make only limited use of expensive special steels and light metal alloys. WH (14)

Materials Employed in Modern Machine Tool Design. B. K. PRICE. *Machine Design*, Vol. 7, Apr. 1935, pages 28-30. See *Metals & Alloys*, Vol. 6, Aug. 1935, page MA 340L/7. WH (14)

14a. Non-Ferrous

G. L. CRAIG, SECTION EDITOR

Modern Uses of Non-ferrous Metals. Edited by C. H. MATHEWSON. American Institute of Mining & Metallurgical Engineers, New York, 1935. Cloth, 5¼ x 8 inches, 427 pages. Price $3.00.

The Seeley W. Mudd Memorial Fund Committee of the A.I.M.E. is sponsoring a series of books for the junior members. This is the 7th of this "A.I.M.E. Series." The volume may for the younger metallurgist, but the older ones will not put it down till they have finished it, once they open it, it is too interestingly written.

Twenty-one eminent metallurgists, of whom we need only mention, Becket, Merica and Jeffries, to give an idea of their standing, have written the chapters, and they have all written simply, clearly and well. We suggest that all technical books and papers be "written for juniors" if by that means the standard attained by this volume can be reached.

The information in the book is very much up-to-date and while terseness has never been chosen in preference to clarity and un-hurried expression, a surprising amount of information on all the non-ferrous metals is packed into it. We shall pass the volume on to many readers in our own organization, and not all of them juniors, either, for it forms the best and the most readable general review of its subject we have seen.

A good index adds to the value of the book. H. W. Gillett (14a) -B-

Amalgam Restorations and the Effect of Manipulation on Alloys. O. M. MIERLE. *Dental Cosmos*, Vol. 77, Apr. 1935, pages 325-333. The author estimates that amalgam fillings are selected for 75% of the restorations in posterior teeth and that in periods of economic distress they are used in 95% of the cases. The composition of dental amalgam alloys is approx. 68% Ag, 27% Sn, 4% Cu, and 1% Zn. The functions of the individual metals are discussed, and the objections to impurities, such as oxides and sulphides, are emphasized. The composition is intended to bring out the best properties of alloys of the individual metals with Hg and to counteract objectionable properties, thus producing what is known as a "balanced alloy." Chemical purity of the Hg used in amalgamation is important, the common impurities being As, Sb, and Sn. The effects of mixing time and packing pressure on dimensional changes and resistance to flow under pressure are shown in curves. The important reaction is the setting of amalgam is $Ag_3Sn + 4Hg = Ag_3Hg_4 + Sn$. The Sn does not form a hard strong compound with Hg. The author advocates the use of a thin coating of oxyphosphate of Zn cement on the cavity wall before inserting the amalgam filling, which gives a better seal and prevents discoloration of the tooth structure. OEH (14a)

The Problem of Materials. III (Beiträge zur Werkstofffrage. III). E. RABALD. *Chemische Fabrik*, Vol. 8, May 1, 1935, pages 155-159. For corrosion resistance Cu should be as pure as possible and it is better when cold worked, such as by hammering, than when soft. Al bronze has good erosion and corrosion resistance, especially against $MgCl_2$ solutions. Cu-Si alloys are also good in this respect. Be-Cu alloys have exceptionally high strength, but are very expensive and do not have especially good corrosion resistance. Ni clad steel is used where a combination of strong steel with good corrosion resistance is needed. The addition of .2% Be to Ni improves its corrosion resistance and Be improves its strength. Cr-Ni and Cr-Ni-Fe alloys are used for parts requiring high heat resistance. Their process of manufacture is more important than their chemical composition. It is necessary to keep them free from C and O. Mg alloys are not used extensively in chemical industry. The addition of small amounts of Mg to Zn base die castings prevents intercrystalline corrosion. The strength of Sn is increased by the addition of .4% Fe and .3% Ni; .5% Sb added to Sn improves its corrosion resistance against dilute HCl. Sb + 4% Fe is resistant to HCl in all concentrations. 30 references. CEM (14a)

Clamps and Joints for Aluminum Overhead Transmission Lines (Klemmen und Verbinder für Aluminium-Ortsnetz-Freileitungen). A. ALMERS. *Elektrizitätswirtschaft*, Vol. 34, June 25, 1935, pages 382-388. Discusses the design of Al cable clamps and precautions to be observed during installation because of certain physical properties of Al as compared with Cu which was the material previously utilized in Germany. 23 models of Al and Al-Cu clamps brought on the market are illustrated and discussed. The use of Cu for transmission cables has been prohibited in Germany owing to raw material shortages. Previous experience with Al cables indicated that a great number of failures could be attributed to faulty clamping methods. WH (14a)

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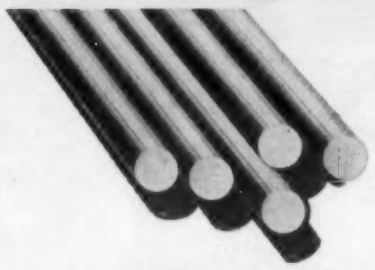

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Further Studies of the Effect of Variations in Manipulation on Dimensional Changes and Flow of Amalgams. MARCUS L. WARD & ERMAN O. SCOTT. *Journal American Dental Association*, Vol. 22, July 1935, pages 1164-1171. The effect of waiting 5 min. after completing the mixing of Hg and alloy (mulling) before packing was studied, using 4 alloys. Amalgams which stood 5 min. before packing contained more Hg than those which were packed immediately, and they always showed more dimensional change, either expansion or contraction, whichever characterized the alloy. For dental practice it is concluded that in case of delay in packing an amalgam filling, the excess Hg should be left in the mix until it can be used, and that this practice has little effect on dimensional changes. The effect of packing pressure on flow under pressure was studied, using cylindrical specimens 4 x 8 mm. and a load of 69.146 lbs., or 3,500 lbs./in.^{2} The alloy contained 70.25% Ag, 25.63% Sn, 2.35% Cu, 1.68% Zn. The specimens were permitted to set for 3 hr. and then loaded for 24 hr. The observed flow ranged from over 10% with little packing pressure (jarring into mold) to about 1% with 80 lb. packing pressure, while a packing pressure of 10 lb./in.^{2} was required to produce a flow which would pass A.D.A. Specification No. 1 (4% flow). The flow of pure gold and amalgam under load (3,500 lb./in.^{2}) was studied over a period of 30 days. Gold showed an initial flow of 0.0049″, while the amalgam showed only 0.0015″. At the end of 30 days gold showed only 0.0057 total flow, while the amalgam showed 0.520, or about 63 times as much flow as the gold. The amalgam alloy used in these tests contained 68.94% Ag, 25.30% Sn, 4.81% Cu, and 0.93% Zn. The conclusion is that pure gold work-hardens so as to stop flow, while amalgam still shows a relatively high rate of flow (.0012″/day) in 30 days. OEH (14a)

Gold Alloys: An Evaluation of Research Data in Relation to Clinical Requirement. STANLEY D. TYLMAN. *Journal American Dental Association*, Vol. 21, Aug. 1934, pages 1426-1440. Read at the 75th Annual Session of the American Dental Association in conjunction with the Chicago Centennial Dental Congress, Aug. 10, 1933. A general discussion along the line indicated by the title. Should be of interest to dentists and metallurgists. 22 references. OEH (14a)

Aluminum in Shipbuilding (Aluminium im Schiffbau). STERNER-RAINER. *Aluminium*, Vol. 17, July 1935, pages 370-374. The various types of Al alloys used in shipbuilding, their manufacture, properties and treatment for corrosion protection are discussed. Ha (14a)

Utilizing Used Tungsten Carbide. LEON SIMON. *Wire & Wire Products*, Vol. 10, Aug. 1935, page 325. Discarded tungsten carbide (of tools) is crushed, treated chemically to remove impurities, and then the particles are fused together without any binder to form new tips of tools which are hard and tough, and not brittle as were the original tungsten carbide tips made with a binder. Ha (14a)

Beer Conduits of Aluminum (Bierleitungen aus Aluminium). A. ROMUND. *Aluminium*, Vol. 17, Aug. 1935, pages 447-448. Al pipes for beer have an advantage over tin pipes or tinned Cu pipes in that the beer does not assume a turbid appearance when standing for several hours in them and, therefore, less waste results. Al is now admitted in the German regulations as permissible material for this purpose. Ha (14a)

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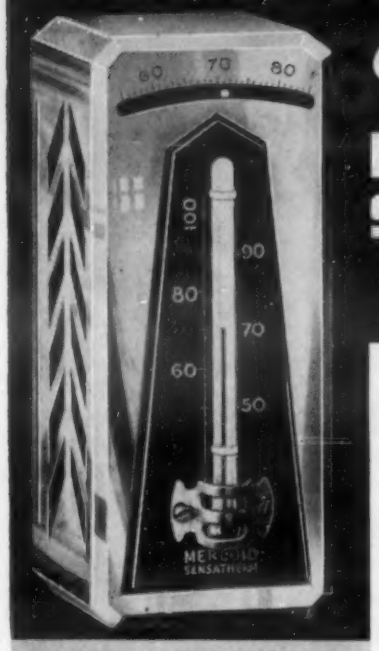

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M. GENSAMER, SECTION EDITOR

1

Steel Used Extensively in Building El Vado Dam. CHAS. P. SEGER. *Engineering News-Record*, Vol. 115, Aug. 15, 1935, pages 211-213. Welded steel plates were used to make a watertight upstream face and to line the spillway channel. Part of the permanent lining of the diversion tunnel was made of steel plates. Details of construction are described. CBJ (14b)

2

Some Mechanical and Metallurgical Aspects of Present-day Oil-production Equipment. ALBERT G. ZIMA. *Metals Technology*, Aug. 1935, *American Institute Mining & Metallurgical Engineers Technical Publication* No. 633, 14 pages. Tools and equipment used in the oil industry are described and the materials from which they are made are discussed. JLG (14b)

3

Modern Steels and Weight Reduction. J. C. WHETZEL. *Preprint American Iron & Steel Institute*, May. 1935, 30 pages; *Steel*, Vol. 96, May 27, 1935, pages 40-44, 60-61; *Iron Age*, Vol. 135, May 30, 1935, pages 33-43; *Iron & Coal Trades Review*, Vol. 130, June 28, 1935, page 1097. The use of low and high alloy steels has resulted in a weight reduction of from 20 to 70%. Tables are given showing the weight reduction and the physical properties of many alloys. Applications and illustrations are given. VVK + VSP + MS (14b)

4

Use of Corrosion Resisting Steels in the Chemical, Especially the Nitrogen Industry (Die Verwendung korrosionbeständiger Stähle in der chemischen, insbesondere der Stickstoffindustrie). PAUL SCHAFMEISTER & FRIEDRICH KARL NAUMANN. *Chemische Fabrik*, Vol. 8, Mar. 6, 1935, pages 83-90; *Technische Mitteilungen Krupp*, Vol. 3, June 1935, pages 100-107. In high pressure NH_4OH synthesis a steel is required which withstands the action of H at 100 to 1000 atm. pressure and 400°-600° C. H decarbonizes ordinary steel and lowers its strength, and its effect increases with increasing pressure and temperature. Cr or Ti are added to steel to stabilize the carbide. At 300 atm. and for a period of 100 hours C steel is satisfactory up to 350°, 2% Cr steel up to 450°, 5% Cr steel up to 600°, .2% Ti steel up to 400°, and .5% Ti steel over 600°. Cr steels are also used for contact with H_2S and 6% Cr and 18-8 for oil cracking equipment. High Cr steels without Ni are not satisfactory for this service. In the process of oxidation of NH_4OH to HNO_3, acid and heat resisting steels are used. In Cr and Cr-Ni steels the corrosion resistance increases with rising Cr content and decreases with rising C content. 18-8 Cr-Ni and 17 to 18% Cr steels are most extensively used for HNO_3 and are better than 13% Cr steel. 18-8 steel is used in breweries, dairies, bleaching and dyeing processes, and with addition of Mo for sulphite pulp, phosphates and fertilizer. 18-8 steel stands near Ag in the electric potential series. 18-8 and Fe make a better metal combination from the standpoint of galvanic action than Cu and Fe or Ni and Fe. If 18-8 steel has been heated to 500°-800° it is subject to intercrystalline corrosion. To prevent this it should be annealed, or a very low C steel, or one with Ti, V or Ta additions should be used. For high heat resistance high Cr steels, with or without the addition of Ni, Al or Si, are recommended. The oxides forming on their surface adhere tightly and prevent further scaling. In the manufacture of nitrates non-aging and alkali resisting steel is required as hot nitrates cause intercrystalline and caustic embrittlement in ordinary cast steel. The action is similar to that in 18-8 steel, oxides and nitrides forming at the grain boundaries. For this purpose Izett steel, which is specially deoxidized, is used. 14 references. Ha + CEM (14b)

5

6

7

Super-Liner "Normandie" Makes Maiden Crossing. *Heat Treating & Forging*, Vol. 21, June 1935, pages 291-292. The steam turbine discs are made of Cr-Ni steel with 36% Ni and 11% Cr, bolts and studs of a 2% Ni annealed steel and of Ni-Cr-Mo steel. The shafts are of steel with 0.15% C, 2.70% Ni, 0.70% Cr. Decorative fittings, hardware and furnishings required 100 tons of 18/8 steel. MS + Ha (14b)

8

Free Cutting Steel. P. HOLMES. *Edgar Allen News*, Vol. 14, Aug. 1935, pages 690-692. Free-cutting steels have been developed for parts where the machining time is a deciding factor of the total production time. Their development, characteristics and uses are discussed. Best results with them are obtained by case-hardening them by the cyanide process; but parts liable to distort should be quenched in oil instead of water. Ha (14b)

9

Stainless Steel Dentures. EDWIN H. MAUK & FRANK C. LARSEN. *Journal American Dental Association*, Vol. 21, Sept. 1934, pages 1541-1554. The authors outline the development of stainless steel under the trade name of "Wipla" by Krupp for dentures. The steel used is designated as V2A and corresponds closely to the 18% Cr, 8% Ni stainless steel in this country. Dentures are made by pressing and swaging sheets, and attachments are made by spot welding. American dentists usually are not equipped to handle this material, because they do not have the presses for swaging or the electric welder; however, these units could be purchased at costs not exceeding other pieces of equipment generally found in dental offices. OEH (14b)

10

Tool Steels for Woodworking. P. MABB. *Mechanical World & Engineering Record*, Vol. 47, June 14, 1935, pages 583-584. Hardness is not the only criterion for judging the cutting capacity of tools for woodworking. Resistance to abrasion is very important which raises special considerations in selection and treatment. The following tool steel is considered to be very suitable: 0.65-0.75% C, 0.35-0.55% Mn, 0.1-0.3% Si, 17.5% W, 4-5% Cr, 1.4% V (minimum) and 0.04% S and P (max.). When small, non-repeating production has to be dealt with, a cheaper steel with 1.2-1.3% C, 0.25-0.35% Mn, 0.15-0.25% Si, up to 0.25% Cr and V, 0.035% S and P (max.) may be employed. Molding cutters, grooving and tonguing tools comprise 0.95-1.05% C, 0.95-1.05% Mn, 0.15-0.25% Si, 0.4-0.6% Cr, 0.2% V (minimum), 0.035% S and P (max.). Another severe job is the cutting out of slots and panel openings in plywood, faced with hard woods or without. High speed steel will also prove to be satisfactory here. A cheaper steel utilized for short runs contains approximately 1.1% C, 0.25% Mn, 0.15% Si, 3.5% Cr, 6% W. The proper heat treatment is given for all of the steels discussed. WH (14b)

15. GENERAL

RICHARD RIMBACH, SECTION EDITOR

Cast Metals Handbook—1935 Edition. American Foundrymen's Association, Chicago, 1935. Cloth, 6 x 9 inches. Price $4.00.

Twenty-two casting experts coöperated in the A.F.A. committees which planned this book, and many more coöperated in the various symposia on cast steel, cast iron and malleable, which former publications have been condensed and brought up-to-date to form the ferrous portion of the handbook. The editorial work, by Bob Kennedy, H. P. Evans, N. F. Hindle and Rebecca Hall has been well done. The symposia have been stand-by reference works and it is a convenience to have them in condensed form in one set of covers.

Including a useful general chapter on casting design, pattern equipment and the like, the ferrous section occupies 345 pages, against only 58 for the cast alloys of Cu, Al, Mg, Pb, Sn, Zn and Ni bases. The treatment of the non-ferrous alloys is less extended than that of the ferrous, and more in the usual hand-book style. Instead of discussing gradations in the alloys and listing many alternative ones, only the more important commercial alloys are dealt with. In many cases the properties of these have to be represented by blank spaces for want of reliable data, and a plea is made for research to fill the blanks. A.S.T.M. or other specifications are given for all the alloys for which such specifications exist. This adds greatly to the usefulness of the book. The binding is substantial, the paper good and the print large. It's the only handbook we can read if we happen to mislay our glasses. It will be most useful to both consumer and producer. Its preparation is another distinct service to the industry amid those constantly rendered by the A.F.A. H. W.Gillett (15) -B-

Are We At the Dawn of a Light-Metal Age? (Stehen wir vor Beginn eines Leichtmetall-Zeitalters?). Willy Machu. *Die Umschau in Wissenschaft & Technik*, Vol. 39, Apr. 14, 1935, pages 297-301. The author's answer is in the affirmative. Attention is directed to the fact that Fe deposits will last only for 80-100 years (?), that there is double as much Al as Fe at a depth of 10 km. below the earth's surface and that the use of Al and its alloys has made unprecedented progress. The commercial applications of light metal alloys are dealt with at length. States that 20% of the total Al production goes into foil. The increasing utilization of Al alloys is ascribed to their high strength, low specific weight, favorable corrosion resistance, machining properties, thermal and electric conductivity and aging possibilities. The present state of commercialization of Mg and Be alloys is discussed. WH (15)

Arsenic. W. G. Rumbold. *Mining Journal, Centenary Number*, 1935, page 5. A review. AHE (15)

Scope of Utilization of Heat Measuring Instruments in Metallurgical Plants (Das Anwendungsbereich von Wärmemessinstrumenten in Metallhütten und Schmelzwerken). E. K Thews. *Die Metallbörse*, Vol. 25, Feb. 15, 1935, pages 209-210; Feb. 23, 1935, pages 241-242. The author discusses critically where instruments should be employed in metallurgical processes and cases where they are superfluous. EF (15)

Metallurgical Progress and the Finishing Industry. L. Sanderson. *Synthetic & Applied Finishes*. Vol. 6, Mar. 1935, pages 294-295. Cr plated C steel twist drills were very successful where high speed steels had completely failed. Cr plated gears failed due to a distinct tendency of the plating to thicken up at the end of one gear. The risk of scratching mirror-surfaced stainless steels in the forming dies is minimized by lubricating the dies with lithopone and linseed oil mixture or by placing thin paper between sheet and highly polished die. Surface discolorations (Fe oxide film) by contact with forming tools are removed by nitrous oxide, passivation treatment or buffing. In the Bullard-Dunn descaling process, the work is made cathode in a hot acid sulphate bath containing a small amount of metal salt, such as Sn-sulphate. A protective film of Sn is progressively formed over the cleaned areas. Si alloy anodes eliminate frequent bath renewal. 16 Cr- 1 Ni steels compete with 18/8. They are more machinable and subject to heat treatment after fabrication. They retain toughness and strength at extremely low temperatures contrary to 18/8. Rustless steel hub caps are embossed, lacquered and bent over the edges of a thicker mild steel backing. Sb, Cu, Ag shavings are forced mechanically into Pb to raise its corrosion resistance. A thin Ag layer is also rolled onto Pb. A Se coating on Mg serves as a protective coating (+ paint coat). Cu or Cd plated Ni-Fe-Al magnets appeared on the market just to be replaced by Co (15-36%)-Ni (10-25%)-Ti (8-25%) magnet steel. A form of magnet is produced by mixing powdered magnetic Fe oxide with Co ferrite and heating to 1000° C. This is still in the experimental stage but has promising characteristics. Metal cutting files have been nitrided. Castings with 20% Cr (or more) are stronger and more ductile if alloyed with N. The same holds for 18/8. Pearlitic alloy steels working satisfactorily at 900°-1100° C. have been developed to replace expensive high-alloy heat resistant steels utilized in enameling stoves. Surface hardening of steels by drawing a blow pipe across the surface followed with a cooling jet of water or air has been perfected in Germany. EF (15)

Ore Testing as a Specialized Service. W. G. Wagner. *Mining Journal, Centenary Number*, 1935, pages 21-22. AHE (15)

New Method and Device for Production of States of High Dispersion (Über eine neue Methode und Einrichtung zur Erzeugung hochdisperser Zustände). B. Claus. *Zeitschrift für technische Physik*, Vol. 16, Mar. 1935, pages 80-82. During electrodeposition the cathode is subjected to mechanical vibrations of great amplitude and very high frequency by a piezo-oscillator and rejects the depositing metal into the electrolyte in high dispersion of a heretofore unattainable degree. The method is suited for dispersing any metal amenable to electrodeposition and allows varying the degree of dispersion by varying the mechanical and electrochemical conditions of the process in a device of remarkable simplicity. ORS (15)

Product Research and Trends in the Steel Industry. A. B. Kinzel. *Mining & Metallurgy*, Vol. 16, Mar. 1935, pages 127-128. From inaugural address as chairman of the Iron and Steel division read at the 144th annual meeting of the American Institute of Mining Engineers. VSP (15)

15a. Economic

Economic Development and Importance of Aluminum (Die wirtschaftliche Entwicklung und Bedeutung des Aluminiums). H. G. Steck. *Aluminum*, Vol. 17, June 1935, pages 297-304. The development of Al producing industries in different countries, their capacities, market conditions and reasons for the still widening application of Al are described. To produce 1 ton of Al under modern conditions, there are required 4 tons of bauxite, 26,000,000 cal., 23,000 kw.hr., 170 kg. NaOH, 630 kg. crude petrol or pitch coke, 160 kg. crude tar, 80 kg. cryolite. As all these materials are nowhere to be found in one place at the most favorable price the site for erecting an Al plant must be selected with regard to these points. Ha (15a)

Economic Viewpoints in Gold Plating (Wirtschaftliche Gesichtspunkte bei der elektrolytischen Vergoldung). M. Kraatz. *Metallwaren-Industrie & Galvano-Technik*, Vol. 33, Mar. 1, 1935, pages 96-97. Based on extensive practical experience, the author sets out to demonstrate "how electro-plating equipment can be improved and rendered more efficient." The statements only concern the electro-deposition of Au. EF (15a)

Economic Importance of Replacement of Obsolete Equipment in Steel Mills. D. M. Petty. *Blast Furnace and Steel Plant*, Vol. 23, June 1935, pages 395-397; July 1935, pages 477-478, 496-497. MS (15a)

Battle Against Waste of Materials (Zum Kampf gegen Materialvergeudung). H. Meyer auf der Heyde. *Metallwaren-Industrie & Galvano-Technik*, Vol. 33, Mar. 1, 1935, pages 98-100. The author points out unnecessary losses of material in galvanizing plants. Detailed cost and economy data are presented. EF (15a)

Mine Production of Gold and Silver in South Dakota in 1934 (Advance Summary). Chas. W. Henderson. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 389, Aug. 16, 1935, 1 page. In 1931 metal mines in S. Dakota produced 486,118.97 oz. Au and 99,741 oz. Ag as compared with 512,403.77 oz. and 125,417 oz., respectively, in 1933. AHE (15a)

Mine Production of Gold, Silver, Copper, Lead and Zinc in New Mexico in 1934 (Advance Summary). Chas. W. Henderson. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 387, Aug. 15, 1935, 3 pages. In 1934 New Mexico produced 27,307.01 oz. Au, 1,061,775 oz. Ag, 23,630,000 lbs. Cu, 18,729,000 lbs. Pb, and 53,043,000 lbs. Zn, an increase of 832.92 oz. Au and decreases of 119,805 oz. Ag, 3,317,000 lbs. Cu, 3,357,000 lbs. Pb and 8,805,000 lbs. Zn. AHE (15a)

Mine Production of Gold, Silver, Copper, Lead and Zinc in Colorado in 1934 (Advance Summary). Chas. W. Henderson. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 386, Aug. 15, 1935, 3 pages. The output from Colorado ores in 1934 was Au 324,923.32 oz., Ag 3,475,661 oz., Cu 11,294,000 lbs., Pb 8,435,000 lbs. and Zn 1,544,000 lbs., increases of 82,095.62 oz. Au, 1,289,521 oz. Ag, 1,627,000 lbs. Cu and 3,632,000 lbs. Pb and a decrease of 1,025,000 lbs. Zn from 1933. AHE (15a)

Mine Production of Gold, Silver, Copper, and Lead in Wyoming in 1934 (Advance Summary). Chas. W. Henderson. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 390, Aug. 16, 1935, 1 page. In 1934 Wyoming mines produced 4,871.36 oz. Au (2,199.95 oz. in 1933), 710 oz. Ag (260 oz. in 1933), 3500 lbs. Cu and 2000 lbs. Pb. AHE (15a)

Mine Production of Gold, Silver, Copper and Lead in Texas in 1934 (Advance Summary). Chas. W. Henderson. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 388, Aug. 15, 1935, 1 page. In 1934 the metal mines of Texas produced 358.74 oz. Au, 854,442 oz. Ag, 29,000 lbs. Cu and 719,000 lbs. Pb, having a total value of $593,828. No Au was produced in 1933, and the Ag, Cu and Pb had a combined value of $406. AHE (15a)

The Aluminum Industry. E. C. Harder & E. V. N. Kennedy. *Canadian Mining & Metallurgical Bulletin* No. 279, July 1935, pages 355-362. Recent advances of the Al industry, the position of Al in the metal industry, and the Al industry in Canada are discussed. AHE (15a)

Secondary Metals in 1934—Advance Summary. J. P. Dunlop. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 382, Aug. 2, 1935, 1 page. The total value of certain nonferrous metals for which the quantity recovered from secondary sources is reported to the Bureau of Mines was $127,286,100 in 1934, $26,017,300 more than in 1933. Most of the increase was due to the greater value of Cu, Zn, Sn, and Sb, for the quantity of such metals increased only 18,450 tons. AHE (15a)

Estimated Electric Power Demands for Certain Electrochemical and Metallurgical Industries in the Pacific Northwest Over a Period of Thirty Years. A. E. Drucker. *Metallurgical Research Bureau, State College of Washington, Information Circular* No. 11, June 21, 1935, 14 pages. AHE (15a)

Iron Industry in 1934—Advance Summary. H. W. Davis. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 383, July 12, 1935, 6 pages. The Fe ore mined in the U. S. in 1934 was 24,587,616 tons, an increase of 40% over 1933, but 35% below the preceding 5-year average. Shipments were 25,792,606 tons, valued at $66,483,846, an increase of 4.7% in quantity and 4.2% in value over 1933. Stocks of Fe ore at the mines decreased 6%. AHE (15a)

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15b. Historical

New Light On Ancient Technical Progress. H. H. Slawson. *Scientific American*, Vol. 153, July 1935, pages 10-11. The manufacture of glass was known from 2600 to 2700 B. C. and terrestial Fe used as blade of a bronze handled dagger before 2700 B. C. WB (15b)

6

The Bow As A Missile Weapon. W. L. Rodgers. *Army Ordnance*, Vol. 15, May-June, 1935, pages 334-343. Discussion of ancient, heavy steel cross-bow with steel bolts (arrows) of various shapes. Other ancient devices for mechanically projecting missiles, bronze cannon and mortars are discussed and shown in photos. WB (15b)

7

An Early History of Oxyacetylene Welding and Cutting in the United States. O. T. Weirs. *Welding Engineer*, Vol. 20, June 1935, pages 22-24. A brief historical sketch since its inception in 1902. Ha (15b)

Early English Lead Mining. J. E. Metcalfe. *Sands, Clays & Minerals*, Vol. 2, June 1935, pages 51-58. A historic sketch of lead mining, deposits and uses since Roman times in England, smelting and desilverization processes, and statistics of production are given. The max. was reached in 1856 with 101,997 tons while in 1933 it had dropped to 49,056 tons. Ha (15b)

8

The Primitive Use of Gold. T. A. Rickard. *Bulletin of the Institution of Mining & Metallurgy* No. 364, Jan. 1935, pages 33-37. Discussion. See *Metals & Alloys*, Vol. 6, June 1935, pages 264 R/7. AHE (15b)

The Primitive Smelting of Copper and Bronze. T. A. Rickard. *Bulletin Institution of Mining & Metallurgy*, No. 364, Jan. 1935, page 31; Feb. 1935, pages 35-37. Discussion. See *Metals & Alloys*, Vol. 6, June 1935, page MA 264R/7. AHE (15b)

9

Ancient Tin Mining in Cornwall. F. B. Michell. *Sands, Clays & Minerals*, Vol. 2, June 1935, pages 89-99. A historical sketch; Sn mining in the British Isles goes back to the 12th century B. C. 16 references. Ha (15b)

The Work of Walter Rosenhain. J. L. Haughton. *Foundry Trade Journal*, Vol. 51, Sept. 6, 1934, pages 153-155. See *Metals & Alloys*, Vol. 6, June 1935, page MA 264R/5. CEJ (15b)

10

With Hammer and Torch (Med. Hammare och Fackla). Sixth Year. Book issued by Sancte Orjens Gille, Stockholm, Sweden, 1935. Paper, 6¾ x 9¼ inches, 185 pages.

A historic review dealing with the early days of the Swedish mining and metal industry. Production of iron plate at Skebo works should be of particular interest. Iron plate was produced in Sweden as early as about 1200, by forging. Rolling was introduced in 1670, and the two processes were worked side by side until the first rolling mill for large plates was built at Kloster in 1801. Skebo mill was put into operation in 1816, with an annual production of about 100 tons. The mill was modernized in 1858 and operated until 1870, with an average annual production of about 360 tons. Other chapters deal with the early days of copper production and its importance to the military importance of Sweden in the Middle Ages; the use of domestic silver and gold in Swedish art work, from the early production about 1400 down to the present day when Boliden has become an important gold producer; and the history of Swedish iron in Norway.

B. H. Strom (15b)—B—

The Parts Vendors Contribution to Aircraft Engine Development. Glenn D. Angle. *Aero Digest*, Vol. 27, July 1935, pages 32-36. Historical survey of metals developments in aircraft field for engines, valves and bearings as the metallurgists contribution. WB (15b)

History of Production and Use of Steel (Aus der Gesichte der Erzeugung und Verwendung des Stahles). Otto von Halem. *Montanistische Rundschau*, Vol. 27, May 16, 1935, pages 3-5; June 16, 1935, pages 3-5; July 16, 1935, pages 5-6. Historic review of metallurgy of iron and steel, going back 5,000 years to the first known production in Egypt, and giving the developments through the Middle Ages up to present time. Discusses the introduction of the more modern processes, such as the puddle process, introduced by Henry Cord in 1784, the Bessemer process, the Thomas process, the open hearth, and the development of the various types of electric steel furnaces. BHS (15b)

The Story of Early Metallurgy. XI. Copper and Bronze: The Question of Priority and the Mineral Sources. R. T. Rolfe. *Metal Industry*, London, Vol. 45, Nov. 23, 1934, pages 485-488; Dec. 14, 1934, pages 563-565, 576. Discusses Copper and Bronze Ages of the ancient civilizations of Babylon, Egypt, etc. A spearhead of almost pure Cu, found in the stratum just above that indicating the level of the great flood, estimated to have occurred at approx. 4000-3500 B.C., shows that metal was used at that time. Possible sources of Cu and Sn in later centuries are considered and suggestions offered why even present day sources may have been used. From the records that have been translated; from weapons and decorations that have been recovered; and from the analyses that have recently been made of these metals, in which the low amounts of impurities were determined, conflicting data have been obtained which make it difficult to learn just where the ancients did obtain these metals. HBG (15b)

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Alloy Still Tubes

High temperature creep values of these low priced tubes are the subject of this leaflet which supersedes Circular Letter No. 2A, dated Nov. 1, 1933. The Calorizing Company, Pittsburgh, Pa. (A 789)

Electric Furnaces

A pamphlet describes the "Certain Curtain" furnace which was developed for heat treating at temperatures between 1850 and 2500 deg. F. C. I. Hayes, Inc., Providence, R. I. (A 790)

Thermit Welding

This new booklet describes this alumino-thermic process for the welding of heavy sections of ferrous metals. Metal & Thermit Corp., New York, N. Y. (A 791)

Modern Metal Treatment

A colorful pamphlet lists the R & H chemicals available for heat-treating, electroplating and for cleaning metals. E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. (A 792)

Properties of OFHC Copper

An attractive booklet contains reprints of three papers relating to the above subject. Photographs, diagrams and photomicrographs are used to illustrate them. United States Metals Refining Co., New York, N. Y. (A 793)

Torsion Impact Testing Machine

Bulletin No. 114 discusses the Carpenter machine whose operation is very simple and requires only one operator. Baldwin-Southwark Corp., Philadelphia, Pa. (A 794)

The Jetal Process

Simple immersion in an aqueous bath for about 5 minutes colors all grades of common iron or steel a brilliant and uniform jet black. It is claimed it does not alter dimensions of articles and cannot chip, scale, peel or discolor. Alrose Chemical Co., Providence, R. I. (A 795)

New Method Annealing

Pamphlet containing data on this method. Illustrated. Power curves, comparison of annealing costs, etc. The Bellis Co., Branford, Conn. (A 796)

Welding Rod

A booklet telling about their Roman Bronze welding rod, and illustrating some of its uses has been issued by the Revere Copper and Brass, Inc., New York, N. Y. (A 797)

"Nothing is Impossible to Industry"

Leaflet descriptive of complete units for oil or gas using special composition cast pots. The Campbell-Hausfeld Co., Harrison, O. (A 798)

Vanadium Facts

Another issue of this publication contains accounts of progress and performance in the field of alloy steels. Vanadium Corp. of America, New York, N. Y. (A 799)

Light Weight Insulating Brick

Therm-O-Flake brick which has low thermal conductivity and is recommended for cushioning furnace binding against expanding brickwork is the subject of a leaflet distributed by the Illinois Clay Products Co., Joliet, Ill. (A 800)

Electric Heating

Data Book No. 236 illustrates and describes space heating by Electromode forced heat. Applications of Electromode industrial, portable and "Bilt-in-Wall" all-electric fan type unit heaters are included. American Foundry Equipment Co., Mishawaka, Ind. (A 801)

Chapmanizing

A pamphlet devoted to Chapmanizing, which is a process of hardening low-carbon steel, compares it to nitriding and carburizing. The Chapman Valve Mfg. Co., Indian Orchard, Mass. (A 802)

Lithorizing

Leaflet setting forth this process for making paint hold to galvanized iron. American Chemical Paint Co., Ambler, Pa. (A 803)

Modern Gathmann Methods

A leaflet illustrates some of these methods and tells why they are vital to makers and users of steel. The Gathmann Engineering Co., Baltimore, Md. (A 804)

Copperoid Steel Sheets

Leaflet illustrating and describing subject indicated. The Youngstown Sheet & Tube Co., Youngstown, O. (A 805)

Machine Gas Cutting

An attractive and well-illustrated booklet tells how this has been made practicable, from both operating and economic standpoints, by the development of the Airco-D-B Camograph. Air Reduction Sales Co., New York, N. Y. (A 806)

K & S Pyrometer

Leaflet illustrating and describing this pyrometer whose manufacturers claim it is the most compact, accurate, lowest priced and simplest to use. Industrial Pyrometer Co., Painesville, O. (A 807)

Free Cutting Brass Rods

Anaconda publication B-14, second edition, lists in detail the advantages of brass for screw machine products. American Brass Company, New York, N. Y. (A 808)

Modern Melting

A looseleaf combination handbook and catalog containing general melting information and a section for auxiliary furnace and foundry equipment giving information on electrodes, refractories, etc., has been issued by the Detroit Electric Furnace Co., Detroit, Mich. (A 809)

Molybdenum in Iron and Steel

An attractive brochure contains a summary of the part played by molbydenum in ferrous progress, and claims that a great saving in cost with no impairment in quality can be obtained by its use. The Climax Molybdenum Co., New York, N. Y. (A 810)

Steam Drop Hammers

Bulletin 255 discusses the Chambersburg Model E Steam Drop Hammers. The advantages of the hammers, whose cylinders are made of Cecolloy, are listed. Chambersburg Engineering Co., Chambersburg, Penn. (A 811)

Alumite Plast-O-Fractory

Bulletin 26, Series A, contains directions for using and recommended applications for this refractory material in plastic, moldable form. Illustrated. The Massillon Refractories Co., Massillon, Ohio. (A 812)

Air Operated Controllers

Catalog No. 8900 gives information on a complete line of these controllers for temperature, flow pressure and liquid level which, according to the manufacturer, meet rigid requirements for accuracy, simplicity, flexibility and adaptability. The Brown Instrument Company, Philadelphia, Pa. (A 813)

Rapid Moore Lectromelt Furnaces

Bulletin No. TC illustrates and describes patented lift and swing-aside-roof type quick top-charge electric melting and refining furnaces. Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa. (A 814)

Special Atmospheres in the Heat Treatment and Razing of Metals

A reprint of the above article by C. L. West, Research Engineer, is offered by The Electric Furnace Co., Salem, O. (A 815)

Rolled Steel for Machine Construction

This attractive booklet contains valuable suggestions on the forms of steel available, short cuts to economy in buying, etc. Illinois Steel Co., Chicago, Ill., and Carnegie Steel Co., Pittsburgh, Pa. (A 816)

J-M Industrial Materials

A profusely illustrated catalog describes insulating materials, refractories, etc. Detailed recommendations by J-M engineers for insulating in certain fields are included. Johns-Manville, New York, N. Y. (A 817)

Stiffness Tester

Bulletin E-10133 is a technical description of Smith Tabor Model "A" Precision Stiffness Tester, for the scientific measurement of stiffness and resiliency. Wilson Mechanical Instrument Co., Inc., New York, N. Y. (A 818)

Nickel and Its Alloys

List A contains many publications on the above subject. Very helpful in completing your files. International Nickel Co., Inc., New York, N. Y. (A 819)

Furnaces

This bulletin illustrates typical examples of this company's furnaces serving the oil industry. Mahr Mfg. Co., Minneapolis, Minn. (A 820)

Interferometer

Bulletin 135 describes and illustrates the Michelson Interferometer and accessories. This instrument has a range of 30 mm. for the study of the Michelson ring system, the calibration of scales, etc. Gaertner Scientific Corp., Chicago, Ill. (A 821)

Testing Machines

A very interesting pamphlet discussing the Amsler Hydraulic testing machines vs. lever type machines has been issued by Herman A. Holz, New York, N. Y. (A 822)

Aluminum Alloy Castings

An attractive booklet contains interesting information on selection, mixing, melting practice, molding practice for sand castings, heat treatment, etc. of these alloys. Arthur Seligman & Co., Inc., New York, N. Y. (A 823)

Pipe

A colorful folder lists and describes the various types of tubular products manufactured by Steel & Tubes, Inc. and Republic Steel Corp., Massillon, O. (A 824)

Hot Plates

The construction of these Multiple Unit Hot Plates which may be used for any work done on gas hot plates is described in this illustrated leaflet, HD 835. Hevi Duty Electric Co., Milwaukee, Wis. (A 825)

Refractory Cement

Bulletin No. 317, describes Q-Chrome neutral-base refractory cement which was designed for severe-service duty. Quigley Company, Inc., New York, N. Y. (A 826)

Hold-Heet Pyrometers

Wall type and Lance type are described and illustrated in Bulletin No. 202. Russell Electric Co., Chicago, Ill. (A 827)

Electric Furnace

The Sentry Model "Y" which is described in Bulletin 1019 is offered especially for small tools, whether hardened on a production or intermittent basis. The Sentry Company, Foxboro, Mass. (A 828)

Steel Treating

"Steel Stamina" contains articles of interest to steel treaters. Attractively illustrated. Lindberg Engineering Co., Chicago, Ill. (A 829)

Hardening Furnaces

Two bulletins, one devoted to oil-fired furnaces and the other to gas-fired furnaces, both of which are made in single and twin chamber models, describe these high speed hardening furnaces. Philadelphia Drying Machinery Co., Philadelphia, Pa. (A 830)

Metallurgy of Wire Manufacture

This paper contains valuable and interesting data and was presented by H. W. Graham, general metallurgist of Jones & Laughlin Steel Corp., Pittsburgh, Pa. (A 831)

U S S High-Tensile Steels

Pamphlet describing high-tensile steels developed to meet the need of the transportation industry. United States Steel Corp., Pittsburgh, Pa. (A 832)

Industrial Application of the X-Ray

Bulletin 284 contains a complete treatise on the above subject. Notes on the selection of equipment. General Electric X-Ray Corp., Chicago, Ill. (A 833)

Arc Welding

A book "Automatic Arc Welding by the Electronic Tornado" gives a full explanation of this system of automatic carbon arc welding for use in industries where products of relatively uniform character are produced in large quantities. Lincoln Electric Co., Cleveland, O. (A 834)

Better Castings

Interesting information is contained in this publication which is distributed by the Niagara Falls Smelting and Refining Corp., Buffalo, N. Y. (A 835)

Zinc Alloy Die Castings

A technical booklet tells the story of the development of the "Zamak" alloys. Tables and illustrations. New Jersey Zinc Co., New York, N. Y. (A 836)

High Temperature Insulation

For all types of heated equipment is the subject of an illustrated leaflet issued by Armstrong Cork Products Co., Lancaster, Pa. (A 837)

Binocular Microscope

Bulletin No. 9 illustrates a number of new constructions in wide field instruments with special reference to an automatic multiple objective nosepiece. E. Leitz, Inc., New York, N. Y. (A 838)

Surface Illuminator

This instrument provides an improved method for illuminating opaque or translucent specimens when examined at low magnifications. Illustrated. Bausch & Lomb Optical Co., Rochester, N. Y. (A 839)

Defects in Steel and Magnetic Alloys

The Magnaflux Test, a rapid non-destructive method of locating these defects is described in an illustrated brochure of the Magnaflux Corp., New York, N. Y. (A 840)

Sixteen Sins of the Cleaning Room

Are listed in a circular for convenience in checking on cleaning rooms. Great Lakes Foundry Sand Co., Detroit, Mich. (A 841)

Colmonoy

Bulletin No. 40 describes this new wear-resistant, corrosion-resistant, heat-resistant overlay metal and its products. Colmony, Inc., Los Nietos, Cal. (A 842)

Effect of Operating Temperatures on the Combustion of Industrial Gas

This bulletin reports results on research devoted to improvements in the application of gas for industrial heating purposes. Considerable information was secured concerning the effect of combustion chamber wall temperatures on the combustion of gas. American Gas Association, New York, N. Y. (A 843)

Hot Rolled Carbon Steel Bars

A leaflet issued by this company gives complete list of standard extras. For information on the sizes this company is prepared to furnish see the booklet "Sizes We Roll." Inland Steel Company, Chicago, Ill. (A 844)

Brackelsberg Furnace

Bulletin No. 197 tells how this furnace lowers the cost of quality castings through the use of the lowest priced fuels, ability to produce quality metal from less costly materials, exceptionally low oxidation losses and low power cost. Other important advantages and design and operation are discussed. Whiting Corp., Harvey, Ill. (A 845)

Tool Steels

This very attractive loose leaf handbook contains detailed instructions for forging, annealing, hardening and tempering each grade of steel with the resulting hardnesses; first, second and third choices for definite applications; general working instructions, etc. Crucible Steel Co. of America, New York, N. Y. (A 846)

Buffing and Polishing Methods

The fourth edition of this reference book and instruction manual contains descriptions of Lea Compound and Learok, which help lower finishing costs according to the manufacturer, and of the Lea method of finishing. The Lea Mfg. Co., Waterbury, Conn. (A 847)

Castings Advancement

Bulletin No. 1 discusses metallurgical castings which today may be purchased to meet most exacting specifications. Graphs comparing Meehanite with other metals are included. Meehanite Metal Corporation, Pittsburgh, Pa. (A 848)

Carbon Tool Steel

A leaflet discussing SKF 100 carbon tool steel, which is a straight carbon, water hardening tool steel of uniform quality contains information on the heat treatment and successful applications. SKF Steels, Inc., 40 E. 34th St., New York, N. Y.

Published by the same firm: "SKF 46" leaflet on an oil hardening tool steel of non-deforming properties and "SKF 711" a leaflet on this practically general purpose steel. (A 849)

CURRENT NEWS ITEMS

New York Steel Treaters Establish a Lecture Course

For the first time in its history its New York chapter of the American Society for Metals will inaugurate an educational lecture course, commencing in January. The program is as follows:

Jan. 7.—"Raw Materials and Pig Iron Production" by R. H. Sweetser.
Jan. 14.—"Steel Making" by John Howe Hall.
Jan. 21.—"Mechanical Treatment of Steel" by F. B. Foley.
Jan. 28.—"Heat Treating in Practice" by J. F. Nyzalek.
Feb. 4.—"Mechanical Testing of Metals" by F. T. Updike.
Feb. 11.—"Introduction to the Metallography of Steel" by J. R. Vilella.
Feb. 18.—"Principles of Heat Treatment" by E. S. Davenport.
Feb. 25.—"Alloy Steels" by Dr. A. B. Kinzel.

The course will be given in the assembly room of the Merchants Association of New York in the Woolworth Building at 7:30 each evening. Members of the chapter will not have to pay for the course but a small charge will be asked of others.

Educational Course for Pittsburgh Chapter A.S.M.

The Pittsburgh chapter of the American Society for Metals, as part of its educational activities, again offers a series of lectures. With the object of giving continuity to the educational program, the lectures this season deal with metals and their properties. The lectures are being presented by men outstanding in their field. As in the past, they are being held at the U. S. Bureau of Mines auditorium, 4800 Forbes St., Pittsburgh. The program follows:

Nov. 19, "Metallographic Tests," Howard Scott; Nov. 26, "Grain Size Determinations," Dec. 3, "Hardness Testing," Dec. 10, "Tool Steel Tests," all by Dr. F. H. Allison, Jr.; Jan. 14, "X-Ray Diffraction Tests," Jan. 21, "The Tensile Test," both by Dr. Maxwell Gensamer; Jan. 28, "Fatigue Testing," R. L. Templin; Feb. 4, "Impact Testing," Jerome Strauss; Feb. 11, "Creep Testing," P. G. McVetty; Mar. 3, "Mechanical Property Relations," Howard Scott; Mar. 10, "Corrosion Resistance Tests," Dr. C. M. Johnson; and Mar. 17, "Electrical and Magnetic Tests," P. H. Brace.

Jerome Strauss Made Vice President of Vanadium

Jerome Strauss, who recently was elected vice president in charge of research and development for the Vanadium Corporation of America, has been affiliated with the company for the past seven years. He is a graduate of Stevens Institute of Technology with a degree in mechanical engineering. Following college Mr. Strauss went with the Illinois Steel Co., at the South Chicago works, his stay there being from 1913 to 1914. In 1914, and until 1917, he was identified with the Western Drop Forge Co. as chemist and metallurgist. During the World War from 1917 to 1919, Mr. Strauss was commissioned in the United States Army, serving the ordnance department in various capacities. In 1919 he was named chief chemist and later materials engineer for the United States Naval Gun Factory at Washington. In 1928 Mr. Strauss went with the Vanadium corporation as chief research engineer, a post he has held until his recent election to the vice presidency.

Book on Metal Cleaning

The Magnus Chemical Co., Inc., 169 South Ave., Garwood, N. J., has issued an attractive book entitled "The Metal Cleaning Handbook." It is intended to provide a ready reference and guide for those directly interested in metal cleaning. There are over 200 pages, copiously illustrated. Among the subjects discussed are: Equipment and Methods, Cleaning Materials, Metals Cleaning Operations, Coolants and Cutting Lubricants and so on.

"Modern Melting" is the title of a hand book or catalogue issued by the **Detroit Electric Furnace Co.**, Detroit. It is directed to those concerned with foundry and high temperature process melting. Its more than 40 pages are taken up with discussions of electric melting in the foundry, electric melting and the public utility, the indirect arc rocking furnace, effect of superheat on cast iron, furnace engineering and so on. These discussions are attractively illustrated. There are also illustrated descriptions of the various types and sizes of the Detroit furnace as well as some advertisements of other companies. It is bound by the spiral wire method.

Metallurgical Lectures at Carnegie

Students in the department of metallurgy at the Carnegie Institute of Technology are being given the opportunity this year of hearing a series of talks by a group of scientists prominent in the field of metals. Thus the students, while becoming acquainted with leaders in the various fields of metallurgy, are also learning first hand the demands and problems of the profession which they have chosen to follow. The lecture series is also an interesting experiment in the value of cooperation between industry and the college. The lectures are given weekly and are part of a regular college course in modern metallurgical practice. The speakers who are cooperating with Carnegie in this unusual course and their topics follow:

E. H. Dix, chief metallurgist, Aluminum Research Laboratories, "Structural Aluminum Alloys"; J. P. Gill, chief metallurgist, Vanadium-Alloys Steel Co., "Tool and Die Steels"; V. V. Kendall, research metallurgist, National Tube Co., "The Engineering Problem of Corrosion"; R. R. LaPelle, industrial heating section engineer, power engineering dept., Westinghouse Electric & Mfg. Co., "Industrial Heating Furnace Problems"; P. G. McVetty, research engineer, Westinghouse Research Laboratories, "Creep and Its Engineering Importance"; W. H. Phillips, vice president, Molybdenum Corp. of America, "Molybdenum, Tungsten and their Uses in Metallurgical Industry"; Richard Rimbach, consulting editor, METALS & ALLOYS: "Metallurgical Literature"; Howard Scott, research engineer, Westinghouse Research Laboratories, "Metals and Alloys in the Electrical Industries"; Jerome Strauss, vice president, Vanadium Corp. of America, "The Use of Vanadium in the Steel Industry"; R. L. Templin, chief engineer of tests, Aluminum Research Laboratories, "Forming, Testing and Design Problems"; and T. D. Yensen, manager, magnetic division, Westinghouse Research Laboratories, "Important Modern Magnetic Alloys and Their Uses."

A.F.A. Sponsors Apprentice Competitions

The apprentice training committee of the American Foundrymen's Association announces that it is to sponsor a contest for apprentices in iron molding, steel molding, and pattern making in connection with the 1936 convention of the A.F.A. to be held in Detroit the week of May 4.

The plans call for preliminary contests to be held by individual foundries or local trade or foundry associations, with the winning castings and patterns from these local competitions being forwarded to Detroit. At Detroit a committee of judges will select first, second, and third place winners in each of the three groups awarding prizes which will be given by the association.

In the last contest sponsored by the A.F.A., which was held in 1931, 39 plants, scattered throughout the United States and Canada, cooperated with some 200 apprentices participating. With the increasing attention given to training personnel, occasioned by the demand for skilled labor, it is expected that the number of plants participating in the 1936 contest will approach the number for 1931.

Four New Chapters of A.F.A. Formed

The American Foundrymen's Association announces the formation of four new chapters during the past six weeks. On Oct. 10, The St. Louis District Foundrymen's Club became the St. Louis District Chapter; on Oct. 17, the Detroit Foundrymen's Association became the Detroit Chapter; on Nov. 8, the Milwaukee Chapter was formed; and on Nov. 15, a group of foundrymen in and around San Francisco formed the Northern California Chapter.

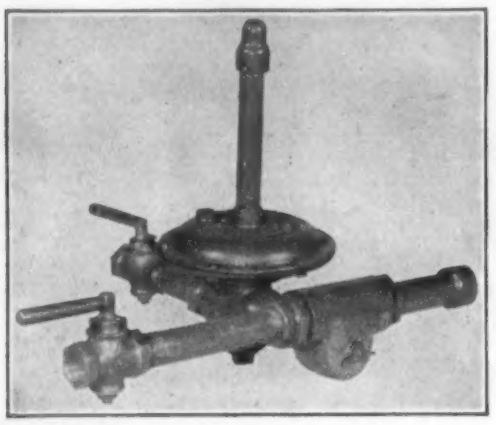
The rapid formation of chapters of A.F.A. indicates the increasing interest throughout the foundry industry in technical advancement and the desire for foundrymen to discuss mutual problems. It is quite probable that further chapters will be formed in other locations in the near future.

There are now eight Chapters of A.F.A., including those recently formed. The first chapter was formed in Chicago in 1934 and this year others were formed in the Quad Cities, Philadelphia, and Cleveland, the latter being known as the Northeastern Ohio Chapter.

NEW EQUIPMENT AND MATERIALS

A New Proportional Mixer

In the many burner applications where close control of atmosphere is necessary for the sake of combustion efficiency and uniform results, it is necessary that the air and gas be delivered to the burners in constant, unvarying ratio. This, in turn, requires that the effect of pressure variations in the gas supply be eliminated. The proportional mixer employed must be capable not only of maintaining the predetermined gas-air ratio at one



rate of firing, but also at varying rates. It must be simple to operate, easily adapted to automatic control, and adjustable to permit desired change of atmosphere or to allow for variation in the heat content of the gas. These requirements are attained efficiently in the "P.D.M. Proportional Mixer," developed by The Philadelphia Drying Machinery Co., Philadelphia.

Essentially, this mixer consists of a diaphragm-actuated control valve, known as a "Zero Governor," which feeds gas at atmospheric pressure to an inspirator into which the gas is drawn and mixed with air. Due to the fact that the gas enters at a constant pressure, the amount of gas inspirated is directly proportional to the quantity of air flowing through the inspirator, causing the two to combine in constant, unvarying ratio, subject to manual regulation by means of a valve controlling the rate of gas flow to the inspirator. The governor is accurate, responsive, lag-free and reliable. For instance, suspension of the control diaphragm from an extra long coil spring and the use of a disc type valve assure sensitive, friction-free operation in immediate response to the slightest pressure change.

Life of Glass Shear Blades Increased 10 Times

Hard-facing alloy, applied to glass shear blades at the Toledo plant of the Libby Glass Mfg. Co., are being used for cutting off the surplus glass from the suction mold used for making blown water glasses. The glass is red-hot and plastic at the time of the cut so that the blades operate at extremely high temperatures. Shear blades hard-faced with Co-Cr-W alloy (Stellite of the Haynes Stellite Co.) outlast the hardened steel blades formerly used at least 10 times and have been standard since 1928. Steel blades simply cannot stand up against the terrific heat and abrasion of the shearing operation. Both tool costs and shut-downs are greatly reduced through the use of the hard-faced blades. Only 1/10 lb. of hard-facing alloy and 5 min. welding time are required to protect each blade.

A 9-in. "Workshop" Lathe

Announcement is made of the 1936 model 9-in. "Workshop" precision lathe by the South Bend Lathe Works, South Bend, Ind. Besides being offered at a new low price, the lathe features 10 new improvements, among which are: A simplified twin gear reverse for cutting right and left hand screw threads of 4 to 40 per in., a countershaft of either the double friction type or the horizontal type with either the plain or adjustable belt tension, a newly improved back-geared headstock with larger spindle bearings and a new ball bearing thrust collar on the spindle, a new and heavier designed saddle, and a simplified gearing for threads and speeds. The lathe has a strong, rigid bed of a one piece casting with 50 per cent steel and 50 per cent nickel iron composition, and comes in four different lengths of 3-ft., 3½-ft., 4-ft., and 4½-ft., with distances between centers of 17, 23, 29 and 35 in. respectively.

This lathe is offered in 8 different models, both in bench and floor leg style for convenience in location to individual needs.

Metals of all kinds can be machined such as: Cast iron, steel, cast steel, steel forgings, wrought iron, brass, bronze, copper, babbitt, aluminum, and the various alloy steels and metals.

Six spindle speeds ranging from 39 to 630 r.p.m. are available on the standard headstock, three obtained on the open belt and three in back gear, the latter with a ratio of 5 to 1, thus permitting a great amount of power to take the heaviest of cuts. Optional is the 4-step cone headstock for V-Belt drive providing 8 spindle speeds, the 2-step double V-Belt drive cone providing four spindle speeds, and the single step triple V-Belt drive furnishing two spindle speeds, all three types designed for extra power.

Line-Arc Magnetic Contactors

For use on mill, crane machinery controllers, and other direct current applications, The Electric Controller & Mfg. Co., 2698 E. 79 St., Cleveland, announces a complete line of new magnetic contactors up to and including 800 amp. capacity, in which the arc, formed as the circuit is opened, is ruptured harmlessly in a narrow path or line centered between, but not touching, the arc shields.

"Line-Arc contactors" are made of a strong aluminum alloy with magnetic parts of rolled steel which has the advantage of light weight and low inertia of moving parts, permitting extremely quick response and high speed operation. Operating coils are designed for continuous operation on direct current voltages of 230 volts or less.

The Line-Arc principle causes the arc to break clean. The arc is not allowed to play around on local areas and, under normal conditions, the contacts never even reach the temperature of electronic emission. Contact life of these contactors has been vastly increased over any existing standards of comparison. There is no consumption of metal in the arcing plate and blow-out guard, because of the constantly changing terminals of the arc and the speed with which the arc is moved along these parts. Therefore these parts should last indefinitely.

"Guthrie-Leitz" Polishing Machine

E. Leitz, Inc., New York, is now marketing an improved type of polishing machine. This instrument represents a material departure from the former model. A few of the many features evident in this construction are:

(1) A specimen holder that will accommodate one to three specimens at a time; (2) A transmission device that causes

the specimen holder to rotate, whereby the specimen receives an automatic motion simulating the one that is usually produced when polishing by hand; (3) Various speeds for the polishing plate from 350 to 1000 r.p.m. are provided for. The speed can be changed while the machine is in action without interrupting the polishing process; (4) A scale index indicates the speed; (5) The magnetic pull upon the specimen can be regulated by means of a dial, depending upon the hardness of the specimen to be polished; (6) A cabinet having storage space, into which the entire grinding and polishing equipment is housed, is an aid to the convenience of the operator; (7) A solution agitator, blowing device and other improvements are provided for.

Timken's New High Temperature Steel

The Timken Steel & Tube Co., Canton, Ohio, has recently released information concerning its new steel "Sicromo," developed "to meet the need for an economical steel for applications when reasonable resistance to both corrosion and oxidation is required." The composition of the steel is: C 0.15 max., Mn 0.50 max., P 0.03 max., S 0.03 max., Si 0.50 to 1.00, Cr 2.25 to 2.75, and Mo 0.40 to 0.60 per cent. Short time high-temperature tensile properties are, from 85 to 1400 deg. F., 74,400 to 12,000 lb. per sq. in. ultimate with a yield strength of 40,650 to 7,500 lb. per sq. in. Complete data on this steel are obtainable from the company.

A Two-Stage Reduction Regulator

The Air Reduction Co., New York, announces a new heavy-duty type two-stage reduction regulator. This regulator, "Airco-DB style 8490," was primarily designed to deliver large volumes of oxygen at relatively high pressures such as may be encountered on heavy cutting, deseaming jobs, furnace tapping and in similar operations. It finds its use principally where the oxygen demand is greater than can be handled by the conventional regulator, or where close pressure regulation and a low end-point are desired. A further and important use of the regulator arises in cases where precise pressure regulation with medium flows is involved. And, whenever the oxygen demand per regulator is in

excess of 1000 to 1200 cu. ft. per hr., the "8490" should be used even if the low end-point and close regulation are not essential.

The Airco-DB Style 8490 regulator is of the two-stage pressure reduction type. The maximum operating pressure is 200 lb. per sq. in. The maximum delivery capacity is on the order of 3000 cu. ft. per hr., providing the delivery pressure is 100 lb. or greater. The pressure regulation furnished by the regulator is practically independent of the rate of flow from full cylinder pressure down to the regulation end-point. The pressure variation will generally be less than plus or minus ½ lb. per sq. in.

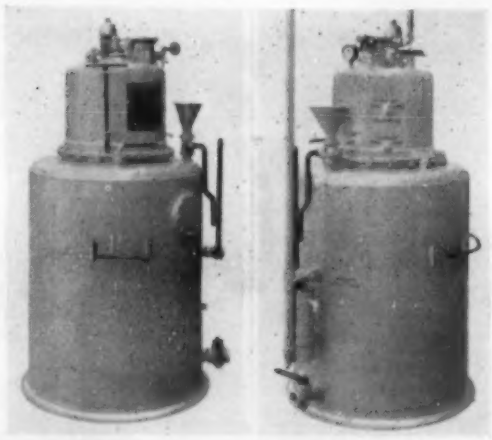
Making a radical departure from conventional regulator design, this regulator uses the Airco laboratory-developed "feed-back" principle. The low-pressure cavity is connected to the space in back of the first-stage diaphragm by the passage through the control tube on the back of the regulator. The first-stage spring maintains a certain difference in pressure between the first and second stages, much in the same manner as in the usual two-stage welding regulator, although the pressure difference varies in the latter for different operating pressures. However, whenever the adjusting screw is turned in, and pressure developed in the low pressure cavity, the same pressure will be developed in the back of the first-stage diaphragm; this pressure augments the effect of the control spring thrust so that the first-stage pressure increases by an amount equal to the operating pressure.

The effect of the control tube is the same as if the first stage side of the regulator were equipped with an adjusting screw of its own and this screw were turned in the same amount as the operating pressure adjusting screw (for equivalent characteristics, a long and heavy control spring would be required). With this arrangement, the difference between the first and second stage pressures is always maintained substantially constant, with the difference being equal to the first stage pressure when the adjusting screw is entirely released.

This feature is largely responsible for the excellent regulation that is obtained with this regulator, because there is a definite relation between the first and second stage pressures which will give the best regulator characteristics. In welding regulators, the available pressure range is small compared to the pressure range of a cutting regulator, thus a varying pressure differential between the two stages is not as important as in the cutting regulator. By using the feed-back principle, the two stages keep pace with each other and the size and weight of the regulator are reduced a great deal over the size and weight of the regulator having comparable performance and using the usual two stage principle. This is because the "8490" regulator uses gas pressure to accomplish what a very long and heavy control spring would otherwise do.

Small Medium-Pressure Generator

A new small-size medium-pressure acetylene generator for portable or stationary service has been announced by the Linde Air Products Co., New York. Known as the "Oxweld Type MP-6 Medium Pressure Generator," this latest addition to the Oxweld line of generating equipment has a 50-lb. carbide capacity with a double rating of 100 cu. ft. of acetylene per hr. Developed for portable or stationary use with any type of oxy-acetylene cutting or welding apparatus, it meets the demand for small, rugged, low-priced generating equipment of modern design.



The Oxweld MP-6 Medium Pressure Generator: (left) for portable service (right) equipped with overflow seal pot, vent tube, and vent pipes for stationary service.

A handwheel at the generator top makes it possible to control the carbide feed so that acetylene at any desired pressure up to 14 lb. per sq. in. may be obtained. The carbide feeding mechanism incorporates the same principle of gravity type, pressure diaphragm-control as the larger Oxweld Types MP-4 and MP-5. Skillful design, and the extensive use of pressed steel parts and bronze-welded galvanized steel sheet result in a neat, sturdy, and extremely compact unit.

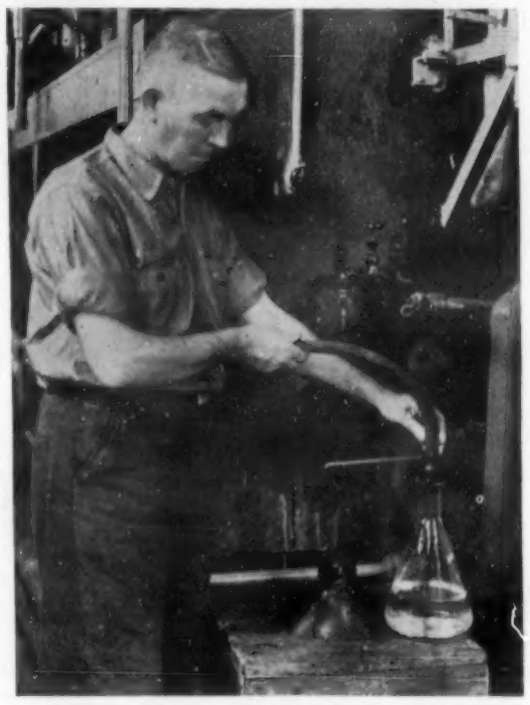
There is practically no exposed piping, and such operating mechanisms as the feed control, carbide hopper, hydraulic back pressure valve, and filter are all assembled within the dome-shaped top of the generator. The dome may be tilted back if access to the interior is necessary.

Special automatic controls make the Oxweld Type MP-6 generator particularly safe to operate. It has been tested and accepted by the Underwriters' Laboratories at the double rating for general capacity. In addition, it has been listed for both stationary and portable service. The generator can be mounted on a truck for transportation from job to job, or fitted for permanent installation to supply medium-pressure acetylene through pipe lines.

Handling Acid With Safety

A new method of ejecting small quantities of acid from carboys has been adopted in the Westinghouse Lamp Co., Bloomfield, N. J., and is expected to minimize the risk in this work.

Acid was formerly ejected by applying air pressure of a few pounds to the carboy, forcing a flow of acid into filter flasks. Now a simple suction device is employed to draw small quantities of acid from a carboy for



use in processing lamp filaments. A filter flask is plugged with a rubber cork and two glass tubes. One tube drops down into the carboy; the other is connected to a rubber suction hose. Air is withdrawn from the flask, creating a suction which draws acid up from the carboy.

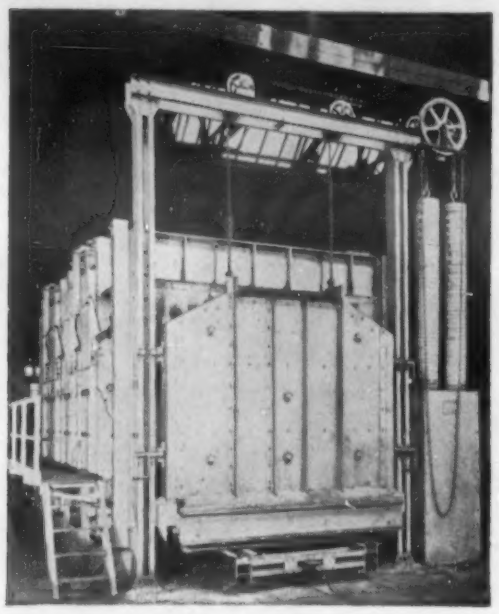
An interesting feature of this ejector device is the method of creating the suction. The rubber hose is attached to the suction side of a laboratory water filter. As air is released from the pressure line through the nozzle of the water filter, it creates a suction in the hose, which, though slight, is sufficient to create enough vacuum in the filter flask to draw acid from the carboy.

A different siphoning arrangement is employed to empty a full carboy into an acid vat at one operation. The carboy bottle is plugged with a cork and two glass tubes, both of which extend to the bottom of the carboy and both of which fill with acid to the level inside. One tube is a siphon that runs out over, and down into the vat below. The other tube parallels the first one and connects with it at the bottom of the bottle. Outside it is topped by a rubber bulb.

Pressing the rubber bulb forces acid up into the siphon tube until it spills over and starts to flow down into the vat below. As the carboy can be emptied easily and safely by this method, danger of acid burns from splashing is practically eliminated.

Improved Heat-Treating Furnace

The Philadelphia Drying Machinery Co., Philadelphia, has found that the use of insulating refractory brick instead of the non-insulating refractory brick assists greatly in securing uniform temperatures. Due to the insulating properties of these brick, operating temperatures are secured in less time, less heat is absorbed by the walls, and thinner walls can be used. These qualities result in a higher operating



efficiency, as a larger percentage of the heat liberated is put to useful work. On account of the low heat storage capacity, the furnace is more sensitive to slight temperature changes, resulting in better control of the work temperature. In most of the older types of furnaces, more heat was required to heat the furnaces than was required for the work treated.

In order to secure the best results from furnaces built of these new bricks, proper burner equipment is just as essential as good furnace design. The furnaces are oil-fired and, in order to obtain good temperature uniformity, a large number of small burners are used rather than a few large burners. These burners produce a short flame similar to gas burners, do not require baffling, and are capable of adjustment over a wide range of capacities.

The furnace shown is used for the heat treatment of steel castings at temperatures between 800 and 2000 deg. F. Uniform temperatures are readily secured in large castings of heavy section. Due to the low heat storage of the furnace walls, some of these furnaces are being used for double treatment of steel castings.

Large Dipper for Coal Stripping

The American Manganese Steel Co., Chicago Heights, Ill., has built an 18-yd. renewable lip dipper, constructed entirely of manganese steel castings with the exception of the bail which is of all-welded high tensile steel.

This dipper was shipped recently to Maumee Collieries Co., Terre Haute, Ind., who will install it on their No. 5480 Marion Shovel in replacement of a 14-yd. dipper weighing 59,000 lb. The 18-yd. dipper has a total weight of 48,850 lb. The shovel is used in stripping overburden from coal, consisting of 20 ft. to 50 ft. of soil, clay, shale, soft stone and hard rock.

The dipper body consists of 3 pieces —back, front and renewable lip. The dipper door is a 1-piece manganese steel casting with hinges cast integrally. The dimensions are: Height of front, including paints, 11 ft. 6 in.; height of back, 7 ft. 3½ in.; overall width, 9 ft. 6 in.; and overall depth, 9 ft. 5 in.

New Automatic Control on Detroit Rocking Furnaces

A step forward toward a completely automatic furnace for controlled electric melting is announced by Detroit Electric Furnace Co., Detroit. Equipment will be embodied as standard on all new models effective for 1936. This improvement provides a means for automatically controlling the rocking cycle of the furnace to compensate for differences and variations in the charge.

The new automatic rocking control Type AR-1 enables the furnace operator to predetermine and repeat the rocking cycle which is most advantageous metallurgically and thermally. The correct cycle may be repeated exactly.

The roof and hearth of the furnace may be alternated on successive heats thus equalizing the wear on the lining with a consequent lowering of lining cost. The device enables the operator to bring the furnace to full rock, automatically, in the shortest possible time so that the charge may be rapidly melted, utilizing the heat stored in the lining, as well as that directly from the arc. The new mechanism will, therefore, it is said, improve thermal economy and aid in reducing melting cost. A distinct advantage is the fact that the rocking cycle may be recorded on the log, together with data as to composition, power input and weight. The metallurgist can add to this the resulting physical compositions obtained and the results are thereafter available for easy duplication. From the point of view of the furnace operator the new Detroit furnace offers longer lining life, increased precision convenience, speed and safety in pouring. It frees him for other work during the rocking cycle which is automatically handled and easily repeatable. This development has been made chiefly to equip new Detroit electric furnaces where it becomes standard apparatus. It has, however, been designed so that it can be applied to practically all Detroit furnaces of the 200-lb. size and upward.

Wilson Arc Welder-Trailer Type

The most sought-for qualities in an arc welding machine are its dependability and durability. The machine illustrated, a "Wilson Gas Engine Driven 300 Ampere" arc welder, mounted on a rubber tired truck trailer has run up an enviable record for both

in its 3-month jaunt around the country, in which it covered all the Airco districts east of the Rockies except Minneapolis. It was towed 10,000 miles over every kind of road imaginable, and in all kinds of weather.

As to its working characteristics, the machine was exhibited at 65 different shows, in charge of 14 different men. At each show from 50 to 150 men used the machine with every type of rod carried by the Air Reduction Sales Co., and practically each man changed voltage and amperage in rapid succession.

A Bench and Pedestal Grinder

The Baldor Electric Co., 4351-63 Duncan Ave., St. Louis, announces the addition of a 12-in. bench and pedestal grinder to its present grinder line. The features of this new product, according to the manufacturer, are: Heavy duty motor, either 2 or 3 h.p., according to preference; exhaust type, hinged guards; adjustable tool rest,

which can be tilted for angle grinding; heavy wide-base pedestal. Standard equipment includes waterpot, tool trays, and starter. The manufacturer offers a free descriptive bulletin to those writing for it.

Cromodine Process for Rustproofing

Excellent rustproofing at a cost decidedly lower than that of any similar process is claimed for a new American Chemical Paint Co. process—"Cromodizing." This treatment changes the steel surface, so that it no longer has the ability to rust. The Chromodized surface, being integral with the steel, is ductile and flexible and therefore will not crack or break when the steel is bent or distorted. Because there is no rough coating formed, paint applied over Cromodized steel has a better luster.

Prominent automobile manufacturers now using this treatment have shown in tests that Cromodizing will at least triple the life of the finish on steel units. In addition the process' low cost enables many products that previously have been denied protection against rust, to be given the benefits of improved and more lasting appearance. To prove Cromodizing's economy, the American Chemical Paint Co. will guarantee the cost of the chemical used in the process, and will bill it at a fixed low rate per 100 sq. ft. of metal processed.

Cromodizing is adapted to protecting any type of steel surface regardless of size, shape or previous processing. Products to be treated are dipped in a bath or sprayed with a solution of a chemical called "Cromodine" for one minute. As is usual, the metal is first cleaned, and following the Cromodine treatment is rinsed, dried and painted. However, less care is necessary in cleaning than is the case with other processes. Large units now in operation are showing an ease of control and a consistency of rustproofing heretofore unknown to the industry.

"Wheelabrator" for Cleaning Metals

In the field of cleaning metal parts, whether castings or stampings, low cost and quality are the two cardinal aims of every manufacturer. It is universally conceded that metal or sand abrasive cleaning gives the most satisfactory results, but this method is reported to be very high in cost because of the expense of compressed air. It is claimed by the American Foundry Equipment Co., Neishawaka, Ind., that this objection has been overcome by the use of what is known as the "Wheelabrator." It is stated that the power necessary to operate this equipment is one-tenth that of compressing air, and that superior results are obtained. Over 150 of these are in operation today, says the company.

The Wheelabrator is a mechanical device for throwing abrasive by centrifugal and tangential force on to the products to be cleaned or for the preparation of a base finish such as the sateen finishing of metal stampings. The method is described as the airless abrasive cleaning and preparation process. It is claimed that drastic reductions in production costs are insured over older methods.

Purolator Filters Cut Chain Costs

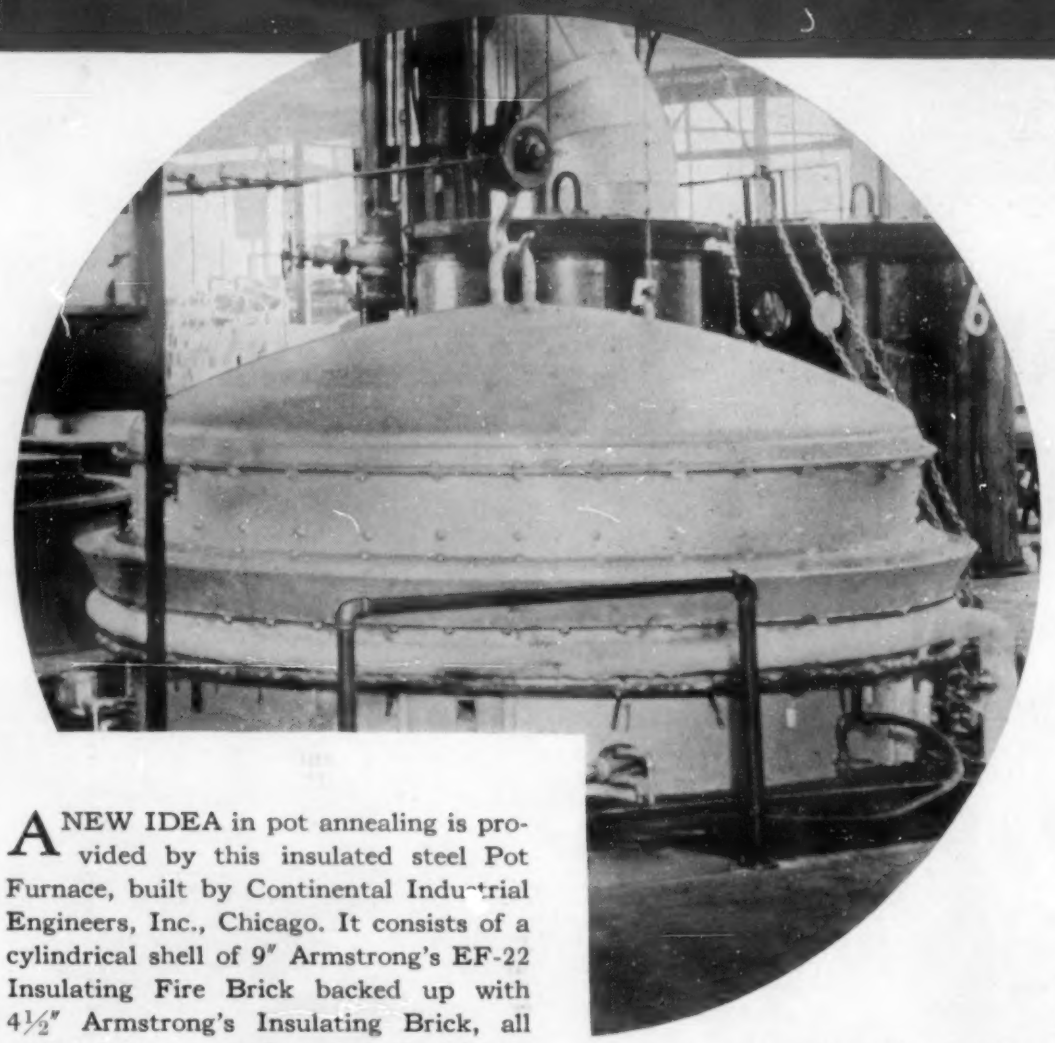
One of the largest companies manufacturing anti-skid chains for automobiles has added filtration of the electro-plating solution to its various processes of manufacture with results that, according to the management, include not only a substantial saving in cost, but a reduction in time of manufacture and an improved appearance of its product as well. This announcement is made by Motor Improvements, Inc., whose engineers proposed filtration to the chain company as an alternative to frequent changes of the plating solution.

The chain company dips its anti-skid chains to make them rust-proof, in a cadmium solution through which an electric current is passed. The chains are carried through a 1000-gal. tank of the solution on an endless conveyor. As this tank is open the solution collects dirt from the air as well as grease from the chains. This contamination was found to cause a dull instead of a brilliant finish on the chains and occasionally left spots unplated or from which the plating chipped away. The only corrective appeared to be to shut down the plating process frequently and replace the solution with a fresh supply.

Engineers of Motor Improvements, Inc., pioneer manufacturer of Purolator lubricating-oil filters for automotive engines and developers of filters for numerous industrial purposes, prescribed a filter with a bag type fabric element of cotton and metal screen reinforcing. Such filters have been used successfully to filter cod liver oil, rayon, cellophane, clear lacquers and varnishes, synthetic resins, and the lubricant used on rolling aluminum sheets. The filter was successful immediately with the cadmium plating solution which is kept in constant flow through the filter and consequently is clean at all times. The filter has overall dimensions of a little less than 18 by 10 in. and the bag may be removed for cleaning and a fresh bag inserted by removal of the filter head which is kept in place by a clamping screw.

NEW POT-TYPE ANNEALING FURNACE

permits greater flexibility and fuel savings



A NEW IDEA in pot annealing is provided by this insulated steel Pot Furnace, built by Continental Industrial Engineers, Inc., Chicago. It consists of a cylindrical shell of 9" Armstrong's EF-22 Insulating Fire Brick backed up with 4½" Armstrong's Insulating Brick, all enclosed in a rugged steel shell which is attached to a steel dome.

Light in weight, this furnace is especially suited for continuous operation. After one pot has been heated the shell is lifted and lowered around another. To speed cooling, a light steel shell with water spray is lowered onto the pot after the insulated furnace shell is removed.

Use of Armstrong's EF-22 Insulating Fire Brick makes possible lighter, thinner walls. And it does more! Because this brick requires no fire brick protection, it cuts down the time needed to bring furnace walls to temperature, saves on fuel bills.

Armstrong's EF-22 Insulating Fire Brick is efficient up to 2200° F. behind the refractory. Other insulating and insulating fire brick made by Armstrong are listed at right. Samples and data on any or all will gladly be sent on request. Address Armstrong Cork Products Co., Building Materials Division, 982 Concord Street, Lancaster, Pa.

Furnace for pot annealing under conditions of controlled atmosphere, built by Continental Industrial Engineers, Chicago.

High Temperature Products in Armstrong's Complete Insulation Line include:

Armstrong's N-16 Insulating Brick for temperatures up to 1600° F. behind the refractory.

Armstrong's N-20 Insulating Brick for temperatures up to 2000° F. behind the refractory.

Armstrong's A-25 Insulating Brick for temperatures up to 2500° F. behind the refractory.

Armstrong's EF-22 Insulating Fire Brick. Light-weight semi-refractory brick for direct exposure up to 2200° F.

Armstrong's EF-26 Insulating Fire Brick for direct exposure up to 2600° F.

Armstrong's V-18 Block. Insulating block for use up to 1800° F.

Armstrong's

HIGH TEMPERATURE INSULATION

MA 525

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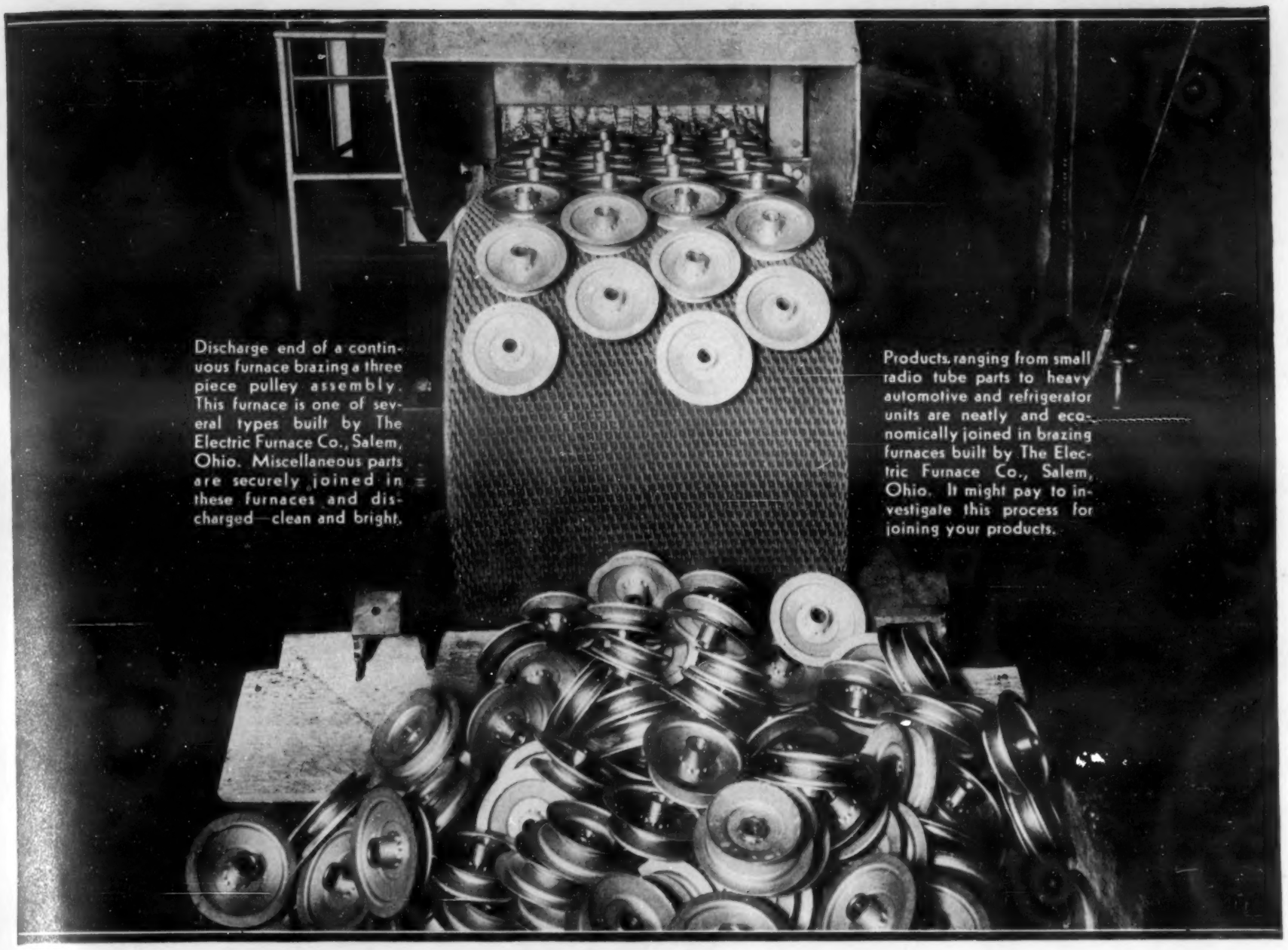

Discharge end of a continuous furnace brazing a three piece pulley assembly. This furnace is one of several types built by The Electric Furnace Co., Salem, Ohio. Miscellaneous parts are securely joined in these furnaces and discharged—clean and bright.
Products ranging from small radio tube parts to heavy automotive and refrigerator units are neatly and economically joined in brazing furnaces built by The Electric Furnace Co., Salem, Ohio. It might pay to investigate this process for joining your products.

Joining Metal Parts —Neater, Cheaper and Stronger

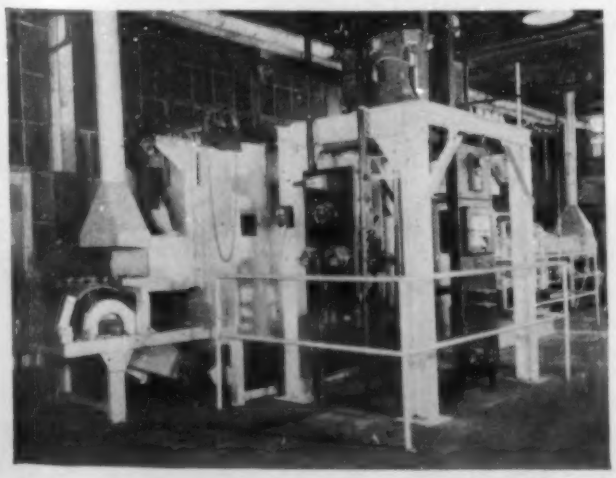
by the continuous brazing furnace method

Metal parts in various shapes and sizes—ferrous and non-ferrous—are being joined neatly, securely and economically in continuous brazing equipment similar to that shown above and below.

The assemblies are loaded on a traveling belt, carried through this equipment in our special, inexpensive atmosphere and discharged, securely joined—clean and bright.

Products difficult or expensive to make in one piece can now be made in several pieces and joined—thus not only reducing the cost but actually improving the quality and appearance.

Products requiring several stampings joined or requiring screw machine parts, forgings and stampings to complete the unit, can be neatly and economically joined right in your own shop.



Charging end of above furnace showing automatic controls, transformers and generator for producing the inexpensive atmosphere used in this equipment.

Any number of joints in the same product or any number of pieces can be joined at one time. The most intricate parts or assemblies are made to actually "grow together," and joints made which are as strong as the original parts.

On some parts it is possible to anneal and braze in one operation.

We will be glad to give you additional information, put samples of some of your products through this equipment to show you the results you can expect, and give you an estimate on the cost of the equipment to handle your production, together with operating cost, etc.

Investigate the brazing process for *your* products. You can join your metal parts, neater, cheaper and stronger by this method.

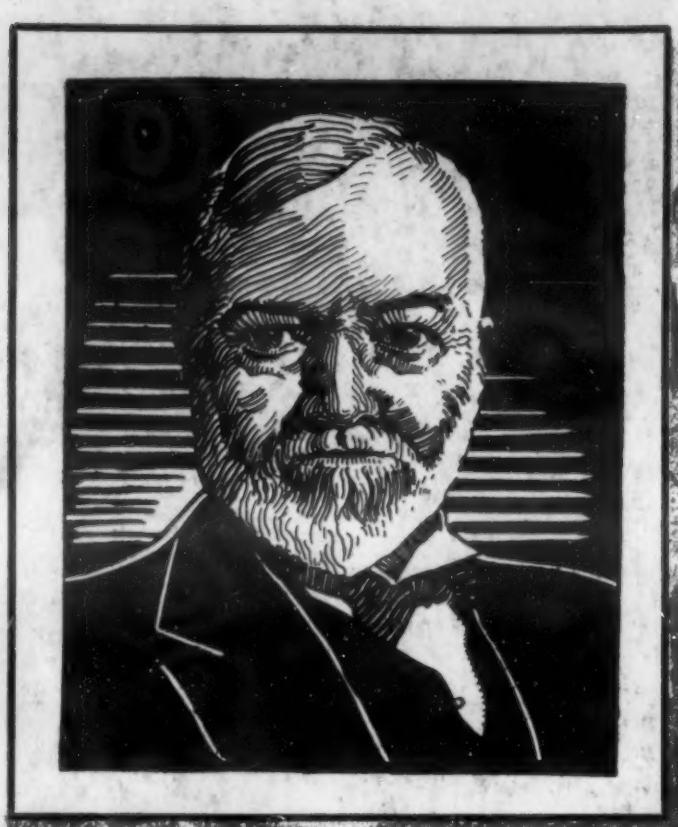
Our engineers will also be glad to discuss our new developments in bright annealing or scale-free heat treating equipment, or work with you on any of your other furnace or heat treating problems.

THE ELECTRIC FURNACE CO.

Fuel-fired Furnaces

Salem, Ohio

Electric Furnaces



Andrew Carnegie

1835 1935

A 4-ton Coreless Induction Furnace Pouring a Charge of Alloy Steel.

He put the God-given smoke in Pittsburgh that signaled the booming of industry, and put food on the workman's table.

The HUMAN INTEREST LIBRARY says;

> "One of the great factors in the success of Andrew Carnegie was that he sought everywhere in the world for the best that would in any way benefit the business. He believed that business men and workers should study everything that was known about a given subject."

With the change to a smokeless era—

Carrying on the same traditions steel men in Pittsburgh are studying the one perfect modern method of heating and melting steel—the Ajax-Northrup Coreless Induction Furnace. We are going full speed to supply the demand not only in Pittsburgh, but also throughout the world.

AJAX ELECTROTHERMIC CORPORATION

AJAX PARK, TRENTON, NEW JERSEY